IMPROVED LONG-TERM PRESERVATION SYSTEM FOR SHIPS' TOPSIDES AND SUPERSTRUCTURES

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Annapolis, Maryland

February 1973

NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER
Bethesda, Md. 20034

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Report 3927
Improved Long-Term Preservation System for Ships' Topsides and Superstructures

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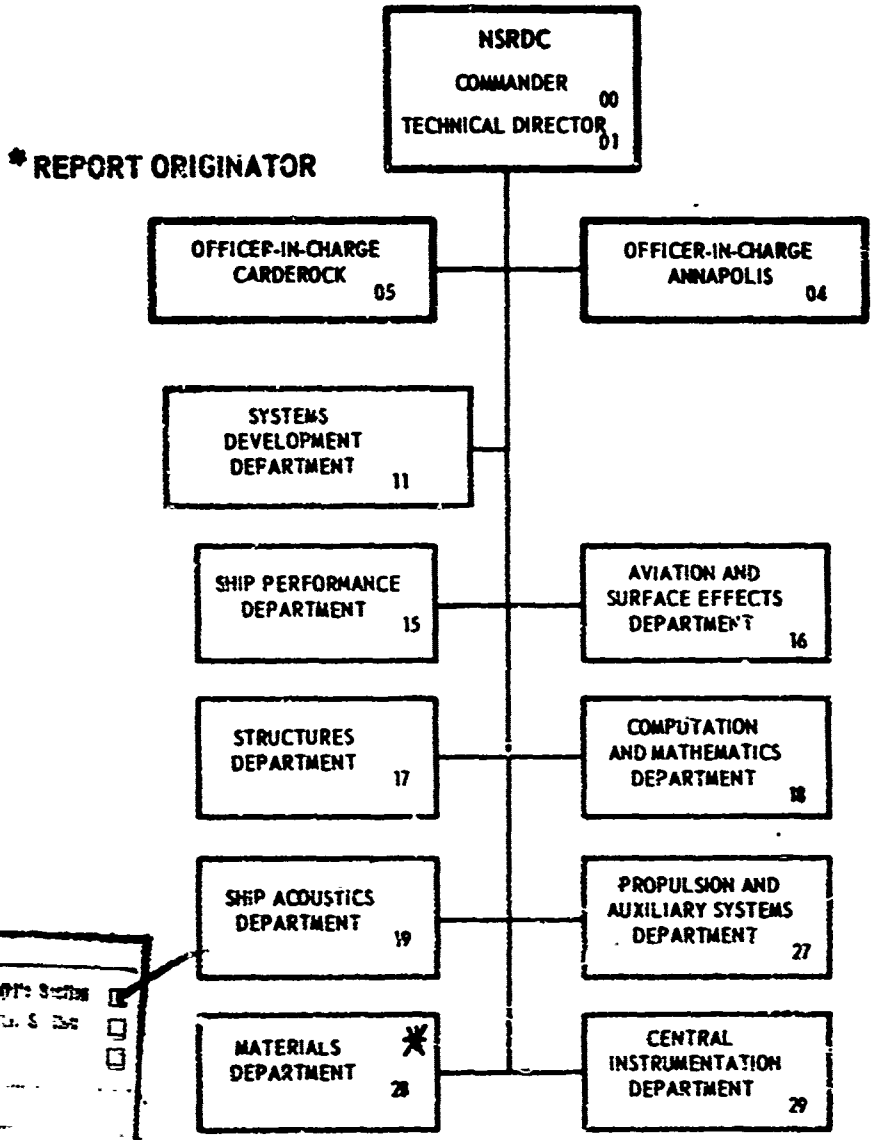

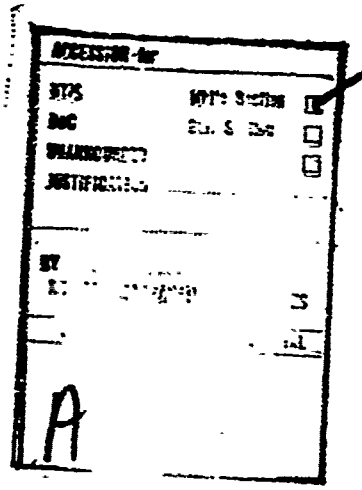

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13. ABSTRACT
An improved system for the long-term preservation of inactive naval ships has been developed. A prototype air-supported structure, within which dehumidified air is circulated, has been installed over the topsides of USS BETELGEUSE (AK 260). Preliminary work on this project was begun in March 1970. Design of the air-supported structure was begun in January 1971; its fabrication was completed by early October 1971; and its installation aboard USS BETELGEUSE (AK 260) at Philadelphia Naval Shipyard was accomplished late in October 1971. By maintaining relative humidity of the air at approximately 35% within the air-supported structure, deterioration of topside superstructure, machinery, and other gear will be minimized. Improved corrosion prevention techniques for the preservation of shipboard machinery and gear have been developed. A time-cost study comparing the current method with the new topside cover method of ship preservation has been made. Over the entire inactivation/reactivation cycle, significant time savings are indicated for the topside cover procedure, especially during the ship reactivation phase. However, estimated costs of the two methods are similar.

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*Du Pont trademark.

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ADMINISTRATIVE INFORMATION

This completed project followed a preliminary feasibility investigation funded by NAVSHIPS (SHIPS 04) in Fiscal Year 1970. Center personnel who participated in the project included Alton W. Waldron, John S. Post, and John W. Cadorette. The project engineer was Dr. H. E. Achilles.

The project was sponsored by NAVSHIPS (SHIPS 03 and 04). The program manager was Mr. E. A. Bukzin, NAVSHIPS (SHIPS 03421); and the technical agent was Mr. A. Winer, NAVSEC (SEC 6101E01).

This final report describes the results of work performed from 1 July 1970 through 31 October 1972. Project direction and guidance are given in references (a) and (b).

ACKNOWLEDGMENT

Major assistance in attaining objectives of the project was provided by the Design Division, NAVSHIPYD PHILA. The cooperation of NAVSHIPS (SHIPS 043), NAVSHIPYD PHILA, INACTSHIPFAC PHILA, INACTSHIPFAC NORVA, and technical cognizance of NAVSEC (SEC 6101) is also acknowledged.

ADMINISTRATIVE REFERENCES

(a) NAVSEC ltr 9190/1, ser: 126-6101E01 of 24 Mar 1970
(b) NAVSHIPS ltr 03421:EB:fm S4624, ser: 154:03421 of 2 July 1970
(c) NAVSHIPS ltr 04312:CES:njs 5050/9190/1, ser: 128 of 6 Mar 1970
(d) NAVSHIPS (SHIPS 04B) Conference Rept 04312:CES:njs 5050, ser: 215 of 1 Apr 1970
(e) CNO Msg 022114Z of July 1970
(f) NAVSEC ltr 6101E:AW:feg 9190/1, ser: 321-6101E01 of 22 Sep 1972

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INTRODUCTION

Extensive technological advances realized during the last 20 years, with respect to materials, techniques, and structural designs, indicated that more efficient means were available to assist in attaining the overall objective of developing a more effective system for long-term preservation of U. S. Navy ships.

OBJECTIVES

Specific objectives included:

- Reduction in time required for the total inactivation/reactivation cycle.
- Reduction in costs for the complete cycle.
- Development of more efficient means to preserve below decks and topside equipment and gear.

APPROACH

One approach, which appeared to hold considerable promise, called for the installation of an air-supported structure made of a durable elastomer-coated fabric over the topsides of a ship, within which dehumidified air was circulated.

In accordance with agreements reached during conferences attended by representatives of NAVSHIPS (SHIPS 034 and 043), NAVSEC, and this laboratory on 13 February and 19 March 1970, authorization* was given for personnel of this laboratory to conduct a preliminary investigation including the following phases:

- Preliminary cover design.
- Engineering feasibility analysis.
- Economic analysis.
- Material studies.
- Preparation of a contract for design and procurement of the cover.

The Design Division of NAVSHIPYD PHILA was tasked to investigate the engineering feasibility of covering the topside of a naval ship with an air-supported structure. This included consideration of cover design as influenced by ship dimensions and

*Authorization is covered by references (a) through (f) in the Administrative Information section, page iv.

geometry, and their relationship to cover deflection, ship stability, mooring loadings, and towing capabilities. NSRDC conducted material studies, made a preliminary time-cost analysis comparing the current conventional method of ship preservation with the proposed topside cover method, and investigated potential specifications which could define the performance of an air-supported structure. The two facilities, along with NAVSEC (SEC 6101), prepared a request for proposals for design and fabrication of an air-supported structure to be installed aboard a ship.

The following key conclusions were reached during the preliminary investigation:

- It was technically feasible to fabricate and install an air-supported enclosure over the topside of a ship.

- It was technically feasible to circulate dehumidified air within this enclosure to preserve the ship against corrosion and other deterioration.

- A naval auxiliary ship would provide a preferred approach for estimating the time-cost effectiveness of the proposed encapsulation method compared to the current conventional method, over the complete inactivation/reactivation cycle.

- Time-cost savings appeared possible if the proposed encapsulation method was applied to an auxiliary ship. USS BETELGEUSE (AK 260) was designated for the prototype cover installation.

- Compared to conventional methods of ship preservation, cost and time savings appeared possible for the topside encapsulation concept if applied to a ship similar to USS BETELGEUSE (AK 260).

A preferred material composition for the air-supported cover was defined, and technical specifications were developed for cover performance suitable for inclusion in a request for technical proposals.

As requested by this laboratory, the final report of the Design Division NAVSHIPYD PHILA[1] is highly detailed in order to provide comprehensive guidance to other facilities which in the future could become involved in similar projects. In view of the detail, this report makes many references to the Design Division's report so as to avoid unwarranted repetition. The following major areas are included in the Design Division's report:

- Cover geometry and configuration.

[1]Superscripts refer to similarly numbered entries in the Technical References at the end of the text.

- Bow and stern enclosures.
- Mooring loading.
- Cover deflection.
- Ship stability.
- Towing.
- Air dehumidification.
- Inflation system.
- Treatment of masts and other projecting superstructure components.
- Emergency power supply.
- Padding of superstructure projections.
- Power.
- Lightning rods.
- Shipyard facilities.
- Cover installation procedure.

In this report the terms "air-supported structure," "topside cover," and "topside enclosure," are used interchangeably, and the term "topside encapsulation," is intended to identify the process of enclosing and preserving the topsides of a ship within an air-supported structure.

Facsimiles of correspondence and supporting information appear in appendixes A through M.

RESULTS

SHIP'S SCHEDULE

Under ideal conditions, the schedule for inactivating AK 260 would have consisted of a 3-month period of preliminary preparations by the ship's personnel followed immediately with work by shipyard industrial personnel, initially for hull preservation, and later for topside modifications and installation of the cover. However, the continuity of this sequence of operations could not be maintained for several reasons. Renegotiation of technically acceptable proposals submitted by offerers was required, changes in basic cover design by the contractor had to be made, and unanticipated delays in procuring satisfactory woven nylon fabric were experienced. Consequently, 6 months elapsed between the completion of work by ship's personnel and the start of work

by industrial personnel. This required some topside blankings, equipment removal, and preservation, all of which would have been otherwise unnecessary. In addition, USS BETELGEUSE (AK 260) was locked in the same dry dock with USS LA SALLE (LPD 3) which underwent extensive overhaul. The time required to complete the overhaul was considerably longer than the time span required for hull inactivation work on the USS BETELGEUSE.

Key events in the schedule for USS BETELGEUSE (AK 260) occurred as shown in table 1.

TABLE 1
SHIP'S SCHEDULE

Date	Event
20 Feb* 1970	AK 260 selected as a candidate ship for prototype encapsulation
2 July 1970	AK 260 designated for prototype encapsulation
15 Oct 1970	Start of inactivation work by ship's personnel at NAVSHIPYD CHASN
15 Jan 1971	Completion of work by ship's personnel; decommissioning of AK 260
19 Jan 1971	Arrival of AK 260 at NAVSHIPYD PHILA
26-27 Jan 1971	Shipboard inspection by contractor
17 Jan 1971	AK 260 dry docked; inactivation work, hull, begun by shipyard personnel
20 Aug 1971	Topside modification begun by shipyard; figure 1-M of appendix M shows AK 260 while topside modifications were under way
10 Sep 1971	Completion of hull work; AK 260 undocked
15 Oct 1971	Completion of topside modifications
19-20 Oct 1971	Topside cover installed aboard AK 260
21 Oct 1971	Postcover installation conference held
23 Nov 1971	Cover acceptance tests completed; product quality assurance and acceptance documents signed

*Abbreviations used in this text are from the GPO Style Manual, 1967, unless othetwise noted.

SOLICITATION AND AWARD OF CONTRACT FOR PROTOTYPE COVER

Background information concerning the preparation of the request for proposals, review of the six proposals received, and final award of the contract to design and fabricate the cover to Birdair Structures, Incorporated, Buffalo, New York, is included on pages 43-45 of the final report.[1] Details of the solicitation and contract are also available.[2,3]

COVER DESIGN/SHIP TOPSIDE MODIFICATIONS

Air-supported structures may be of single- or double-wall construction. Each type has its advantages as described on pages 8 and 9 in the final report.[1] After consideration of all factors, including tradeoffs, the less costly single-wall design was selected.

Prior to award of the contract, the contractor's concept of the air-supported structure had been limited to a stressed skin which transferred its load to its edges uniformly through transverse tension. However, only after the contract had been awarded was the contractor able to make a detailed computer study of the fabric pressure distribution and the stresses which were involved. The study disclosed problem areas of excessive cover deflections, flutter, and overstressing.

Generalized solution of the problems is described on pages 47 and 48 of the report.[1] In the final cover design, the warp of the fabric of the cover material was oriented fore and aft. Transverse wire cables spaced approximately 17 feet apart, which would absorb end reactions from the fabric, were bonded to the outside of the cover. These cables were fastened to the ship's hull. A sealing flap was bonded to the inside of the cover in a position close to its edge. The flap then was sealed to the ship with pressure-sensitive tape to minimize loss of dehumidified air from within the air-supported structure. Figure 1 is a schematic representation of the concept as implemented.

Numerous modifications to the topside of AK 260 had to be developed to accommodate the cover. Design of the modifications to the ship had to be integrated closely with design of the cover to assure maximum compatibility. This required close cooperation and continuous communication between the Design Division and the contractor. Progress of the work was monitored by NSRDC.

Details concerning design problems, cable reinforcing, mooring station enclosures, plans to install the cover, the need for longitudinal support cables, padding of projecting topside superstructure components, attachment and sealing the cover to the hull, and its installation are included in separate sections of the report.[1]

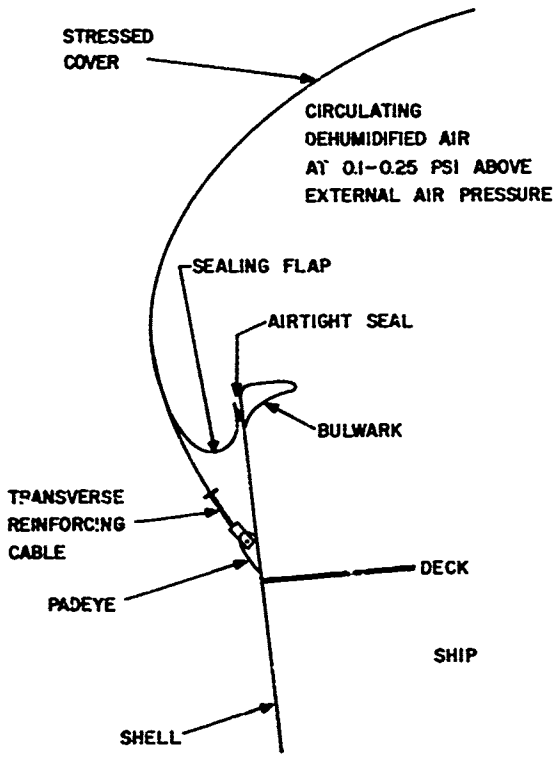


Figure 1
Topside Encapsulation Concept

At the direction of the Commander, NAVSHIPYD PHILA, the Value Engineering Branch made an independent study with the objective of recommending time and cost saving improvements which could be incorporated into future installations. Results of the study are reported in enclosure (9) of the report.[1] Recommendations of the branch are combined with those of the Design Division on pages 70 and 71 of the report.[1]

MATERIALS OF CONSTRUCTION OF COVER

Cover Fabric

As indicated previously in the Introduction, one of the results of the preliminary investigation was the definition of a preferred material combination for the air-supported cover. This combination consisted of a woven Dacron* fabric coated with Hypalon,* or with Hypalon on the exterior and Neoprene* on the

*Registered trademark of E. I. du Pont de Nemours and Company.

interior surface. A minimum target life of 15 years for the material when exposed to the environment was sought. However, it was realized that other material combinations likely could perform equally well under similar environmental conditions. Accordingly, in the solicitation[2] offerers were given the opportunity of quoting on alternate material combinations, provided that they supplied proof of service performance equivalent to that expected of the preferred combination.

The contractor proposed use of a Neoprene-coated nylon fabric which he had employed successfully in the fabrication of many radomes and shelters. He planned to paint the outer surface with a specially compounded Hypalon base paint which had been found to have excellent weatherability characteristics. One confirmation of the good service performance, which could be expected of the material combination proposed by the contractor, was received during telephone discussions with Mr. A. Carletti, Branch Head, U. S. Army Natick Laboratories, who has had wide experience with air-supported structures.

The soundness of the contractor's proposal also was verified by service performance records of single-wall air-supported structures, as shown in appendix A. The data indicated that a minimum target life of 15 years for the cover to be installed aboard AK 260 should be attainable.

Two different woven nylon fabrics were used for fabricating the cover installed aboard AK 260. A 2 x 2 basket-weave (6 ounces per yard) fabric was used for covering the bow and stern ends of the ship where relatively low stresses prevailed. A more tightly plain-woven (8.5 ounces per yard) fabric was used for all other sections of the ship. Two coats of Neoprene were applied to the nylon fabric. The initial brush-on coat was equivalent to a primer tie-coat which assured adhesion integrity of the second calendered coat. Total coating weight was approximately 22 to 23 ounces of Neoprene per square yard, balanced equally on both sides.

The contractor's specifications of the two nylon base fabrics are shown in table 2.

The contractor's specifications of the two Neoprene-coated nylon fabrics are shown in table 3. Design of the total cover system took into consideration the specifications of all materials involved.

TABLE 2
NYLON BASE FABRICS, CONTRACTOR'S SPECIFICATIONS

	Weave	
	Basket	Plain
Type	High tenacity filament nylon	
Weight, approximate	6 oz/yd^2	8 1/2 oz/yd^2
Count, typical	28 x 26	34 x 30
Yarn, No.	840/1	
Weave, typical	2 x 2 basket	Plain
Finish	Scoured and heat set	
Gage, approximate	0.018	

TABLE 3
NEOPRENE-COATED NYLON FABRIC, CONTRACTOR'S SPECIFICATIONS

Properties		Fabric, weave	
		Basket	Plain
Coated weight, oz/yd		28-31	28-31
Coating distribution		Balanced	Balanced
Approximate thickness, in.		0.03125	0.03125
Minimum useable width, in.		60	60
Minimum strip tensile strength, lb/in. width (2 in./min loading rate)			
Dry	Warp	400	525
	Fill	370	450
Wet	Warp	400	525
	Fill	370	450
Minimum Trapezoidal tear, lb			
	Warp	45	70
	Fill	45	70

Transverse Stiffening Cables

Stability and buoyancy criteria for naval ships include a capability to withstand a minimum wind velocity of 100 knots when at sea.[4] Inactivated ships occasionally are towed in the open sea from one facility to another. Consequently, a topside air-supported structure also must be capable of survival when exposed to 100-knot winds.

Detailed stress studies by the contractor disclosed that for the cover to withstand extremely high wind velocities it was necessary to stiffen the enclosure with transverse steel cables bonded to the outer surface of the cover as shown in figures 2-M through 5-M of appendix M. Inflation of the structure resulted in a compression fit of the fabric against the cable so that the latter was in hoop tension. The cables were spaced approximately 17 feet apart along the length of the cover. Strands at the ends of the cables were spread, fitted into cone sockets of clevis assemblies, and held in place with molten zinc, as shown in figure 6-M of appendix M. The clevis was attached through a clevis pin to a padeye welded to the hull of the ship, as shown in figure 7-M of appendix M.

Pertinent information concerning the cables is shown in table 4.

TABLE 4
TRANSVERSE CABLES, KEY PROPERTIES

Property Identification	Requirement
Material	Improved plow steel
No. of strands	5
Wires per strand	25
Lay	Standard
Preformed	Yes
Galvanized	Yes
Cable diameter, in.	1
Weight per foot, lb	1.87
Pretensioned to pull, lb	40,000
Breaking strength, maximum, lb	90,000
Anticipated bonding stress capability, maximum, lb	45,000
Loading at padeye, equivalent to 6-in. water gage pressure	
No wind, lb	11,000
100-knot wind, lb	45,000

BASE CABLE AND CABLE CLIPS

The base or catenary cable is bonded with Neoprene cement within a sleeve of the cover material which in turn is bonded to the cover's sealing flap along its entire peripheral edge. A clip is bent double around the sleeve within which the cable is bonded. A hole is drilled through both ends of the clip so that it can be fitted over a 7/16-inch-diameter threaded stud which is welded to the ship's hull. The clip is then fastened to the stud with a nut. A sketch of the assembly is shown in figure 2.

Key characteristics of the base cable are shown in table 5.

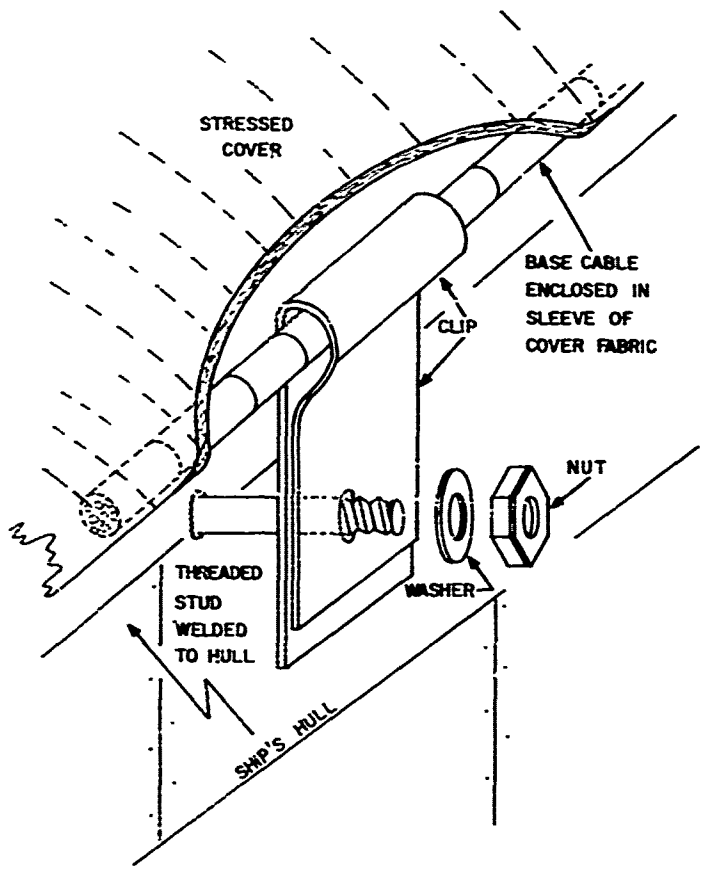


Figure 2
Attachment of Base Cable to Ship's Hull

TABLE 5
BASE CABLE, KEY PROPERTIES

Property Identification	Requirement
Material	Steel
No. of strands	7
Wires per strand	19
Galvanized	Yes
Lay	Standard
Cable diameter, in.	0.375
Coating on cable	
Cable bonded to cover	Neoprene
Cable exposed to weather	Polyvinylchloride

The clips are made of a galvanized steel and have the following dimensions (given in inches):

Length - 4
Width - 1 1/4
Thickness - 1/8

BUTYL SEALING TAPE

The pressure-sensitive tape was supplied by Inmont Corporation (their style 177.1) and meets requirements of the specification.[5] The adhesive tape was selected by the contractor as the best of a group of sealants which he had evaluated. His tests included evaluation of its adhesion to the finished cover material and Navy haze-grey paint on steel panels supplied by the Design Division, NAVSHIPYD PHILA, and its ease of removal as during reactivation. Key characteristics of the sealing tape are shown in table 6.

Commercial experience with this adhesive tape has been highly satisfactory according to the supplier. It has provided excellent weather resistance as a sealant for windows of automobiles and over-the-road trailers, and as a barrier to prevent entry of water into vaults.

TABLE 6
SEALING TAPE, KEY PROPERTIES

Property Identification	Requirement
Type	Butyl mastic
Dimensions, in. Thickness	0.125
Width	0.375
Composition	100% solids (nonvolatile)
Aging	Nonhardening, nonshrinking, retains flexibility for extended period
Toxicity	None
Odor	Bland
Corrosiveness	None
Staining	None
Resistance to solvents, mild acids and alkalies, ethyl alcohol, and water	Excellent
Resistance to ultraviolet	Excellent
Applicability	Readily painted over

HYPALON PAINT

The outer surface of the cover was painted with Hypalon paint which has excellent weatherability characteristics, including protection against ultraviolet rays. The paint was supplied by Dexter Midland, Rock Hill, Connecticut (their formulation 23-5492B). The curing agent in the paint is tribasic lead maleate which provides superior water resistance over other curing agents.[6] Cure of this paint is substantially complete in about 2 weeks and is accelerated when exposed to a warm, moist environment.

Hypalon paint applied to radome covers must meet all specification[7] requirements. Except for the electrical transmission requirement, which is irrelevant with respect to the current application, all other requirements provide a suitable basis for this application of the Hypalon coating.

Compositions of Hypalon paints may vary widely depending on their intended end use. The paint applied to the cover installed aboard AK 260 was selected by the prime contractor, Birdair Structures, Incorporated, in view of many years of

proven performance when applied to radome covers, shelters, etc. The paint provides excellent protection against ultraviolet radiation, which is especially harmful to the nylon fabric of the cover, and it has a relatively low level of permeability for water and air. Discussions with representatives of Bell Telephone Laboratories, Du Pont, and B. F. Goodrich support the opinion that life of the paint coat applied to the cover aboard AK 260 could approach 7 or 8 years before major refurbishing is required.

Worn coats of Hypalon paint can be refurbished readily. The coat is first washed with water containing a detergent in order to remove dirt and other particulate matter. After it has dried, the coat is wiped with toluol in order to get rid of oily deposits which may not have been removed with the detergent solution. The toluol also softens and imparts a slight tackiness to the existing coat which assures better adhesion by the refurbishing coat.

NEOPRENE CEMENT (ADHESIVE)

Neoprene cement was used to bond adjoining sections of the cover. Ten parts of the cement are mixed with one part of accelerator immediately before bonding. Bostik cement (No. 1205) and accelerator 9 are supplied by the USM Company.

COVER FABRICATION

Fabrication of the cover by the prime contractor was delayed because of fabric procurement problems. The 6-ounce basket-weave nylon fabric originally selected by the contractor displayed excessive bias, bow, and bagginess. Complete information regarding the unexpected defects appears in enclosures (6) and (7) of the final report.[1]

In order to avoid excessive delay in fabricating the cover, the contractor used only acceptable portions of the finished basket-weave fabric for the bow and stern sections of the cover. The finished heavier weight (8.5 ounce) plain-weave fabric was used for the more highly stressed midship sections of the cover.

Because of its large size the air-supported structure was made up of sections to facilitate handling. Each section consisted of panels. Adjacent panels were bonded together by means of cemented lapped joints. Each panel was patterned to compensate for stretch in order to assure the correct final geometric shape.

PADDING OF SHIP'S SUPERSTRUCTURE

It was necessary to pad projecting superstructure components to prevent damage to the cover structure during its installation and also when exposed to high winds after installation. A padding material already available at the shipyard was used to minimize

procurements. Sheets and tubes of a soft, unicellular specification[8] polyurethane foam about 3/4 inch thick, were wrapped around projections with which the cover would be likely to make contact. The padding had a rough surface which proved to be a time-consuming hindrance when the rough surfaced cover was eased over padded projections during draping and fitting operations. In future installations, every effort should be made to use padding with a smooth surface such as bald rubber tires, used linoleum floor covering, or similar materials. The padding installed on the crosstree of the aftermost mast, the aft starboard gun tub, and starboard bridge wing of AK 260 is shown in figure 8-M of appendix M.

COVER INSTALLATION

The contractor specified that the cover should be installed only under favorable weather conditions, that is, winds with a velocity below 10 mph, temperatures above 35° F, and in the absence of rain. Also, he wished to complete draping and preliminary inflation of the cover within 1 day.

For several reasons, the installation date of the cover slipped to [illegible] October 1971. This was discouraging because local weather bureau reports indicated that blustery, changeable conditions could be expected on this date. Strong winds did occur then and it was necessary to postpone cover installation to the 19th. Unanticipated problems developed during the draping and fastening of the cover so that installation and preliminary inflation of the cover could not be completed until late on the 20th. Details concerning the problems which developed and their on-site solution are described on pages 57 through 63 of the final report.[1] Highlights of the installation of the cover appear in figures 9-M through 19-M of appendix M.

In view of the problems which had developed, a conference was held on the following day to solicit comments and suggestions which could expedite future cover installations aboard ships. Specific items recommended for further consideration are summarized in appendix B.

AIR PRESSURIZATION SYSTEM

Air intake blowers of the air pressurization system automatically maintain the required pressure inside the structure. There are two low-pressure and two high-pressure blowers. One of each rating is intended for standby service. For wind velocities below 30 knots, internal air pressure is maintained at 2-inches water gage. When wind velocity exceeds 30 knots, a high-pressure blower cuts in automatically to increase the pressure to 6-inches water gage so that the structure can withstand the greater impact pressure caused by high velocity winds.

The inflation system was designed by the prime contractor and was installed as directed by NAVSHIPYD PHILA on hatch cover 3. Manufacturer, model identification, and operating characteristics of the low- and high-pressure air blowers are listed in appendix C.

Additional details concerning the air inflation system are included on pages 29 and 30 of the final report.[1] Figure 20-M of appendix M is a view of the air blowers and air intake ducts of the system.

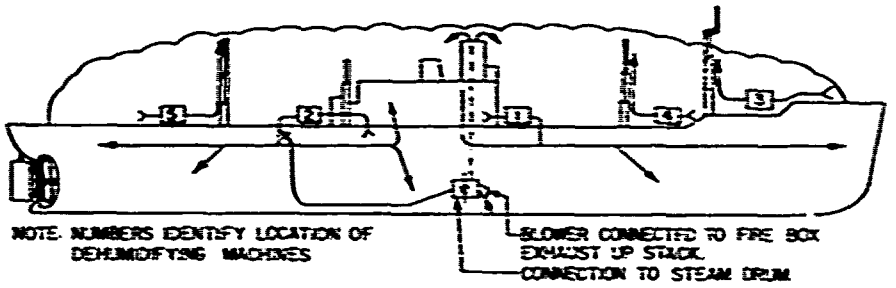
AIR DEHUMIDIFICATION SYSTEM

Detailed information concerning the air dehumidification (D/H) system installed aboard USS BETELGEUSE (AK 260) and its performance characteristics is included on pages 26 through 29 of the final report.[1]

The system serves approximately 1,700,000 cubic feet of air enclosed within the interior of the hull and the topside cover, and includes five rotary-type air dehumidification machines, standard size 55-500, each rated to serve a nominal ship space of 400,000 cubic feet of air. Requirements and details regarding the construction and operational capacities of individual models are provided by specification.[9] To each D/H machine, INACTSHIPFAC PHILA personnel connected several humidistats, each of which was positioned in a different location and could activate the machine if the relative humidity (RH) in its vicinity rose above approximately 35%.

Circulation of dehumidified air through the ship is shown in figure 3.

Locations of the D/H machines and humidistats are given in table 7.



Courtesy of NAVSHIPYD PHILA.

Figure 3
Circulation of Dehumidified Air Through USS BETELGEUSE (AK 260)

TABLE 7
LOCATIONS OF AIR DEHUMIDIFICATION MACHINES AND HUMIDISTATS* ABOARD USS BETELGEUSE (AK 260)

Machine No.	Humidistat No.	Location
1	-	On center line aft of hatch 3, main deck
	1 H_1	Main deck, frame 9
	1 H_2	Hold, frame 50
	1 H_3	Hold, frame 71
	1 H_4	Chart room
	1 H_5	Galley, inside passage
2	-	Forward starboard corner hatch 4, main deck
	2 H_1	Lower level, machinery stage
	2 H_2	Second deck, frame 119
	2 H_3	Hold, frame 121
	2 H_4	Laundry, aft frame 137
	4 H_4	Cabin deck, frame 78
	5 H_4	Cabin deck, frame 97
3	-	Aft starboard corner, hatch 1, forecastle deck
	3 H_1	Forecastle deck, frame 19
	3 H_2	Top of hatch 1, frame 25
	3 H_3	Forecastle deck, frame 35
4	-	Aft port corner, hatch 2, main deck
	4 H_1	Top of hatch 2
	4 H_2	Main deck, frame 51
	4 H_3	Top of hatch 3, frame 60
	4 H_4	Cabin deck, frame 78, connected to machine 2
5	-	Port side, hatch 5, main deck
	5 H_1	Main deck, frame 120
	5 H_2	Top of hatch 5, frame 135
	5 H_3	Main deck, aft, frame 151
	5 H_4	Cabin deck, frame 97, connected to machine 2

*Under supervision of INACTSHIPFAC PHILA.

COVER PERFORMANCE

Approximately 90 days usually are required to "dry out" a ship similar to AK 260. However, in the case of AK 260 there was no opportunity to determine the length of the drying-out period, because the air within the interior of the hull already had been dehumidified before installation of the topside cover. Humidity of the air when the cover was inflated on 20 October 1971 was relatively low. Consequently, only a short period of time elapsed before RH of the air within the dehumidification zone had dropped to below 40%. On 13 December 1971, RH of the air was measured at all humidistat locations with a wet/dry bulb hygrometer by INACTSHIPFAC PHILA with the results shown in table 8. At all positions, RH was well below the acceptable 40% level.

TABLE 8
RELATIVE HUMIDITY OF AIR ABOARD USS BETELGEUSE

Humidistat* No.	Air Relative Humidity, %
1 H_1	31
1 H_2	20
1 H_3	22
1 H_4	28
1 H_5	28
2 H_1	27
2 H_2	27
2 H_3	28
2 H_4	29
3 H_1	28
3 H_2	25
3 H_3	29
4 H_1	31
4 H_2	27
4 H_3	29
4 H_4	27
5 H_1	29
5 H_2	27
5 H_3	28
5 H_4	26

*Under cognizance of INACTSHIPFAC PHILA.

In several isolated instances, when a machine operated over 50% of the time, the causes were discovered and quickly corrected. A faulty humidistat was the cause in one case and an accumulation of water in a chain locker in another. Less than 40% RH was maintained in each instance, indicating adequate capacity and satisfactory controls in the dehumidification system.

Nine combination RH/temperature sensors connected to a continuously recording potentiometer were installed at different topside locations by NSRDC personnel. Thus, an uninterrupted record of daily RH and temperature fluctuations could be obtained. Locations of the sensors are given in table 9. RH and temperature of ambient air was registered by sensor 1. A sensor also was installed on the top of the stack where maximum daily fluctuations in RH and temperature were expected.

TABLE 9
LOCATIONS OF RELATIVE HUMIDITY/TEMPERATURE SENSORS ABOARD USS BETELGEUSE

Sensor No.	Location
1	Outboard, starboard midships mooring station, frame 65
2	Top of hatch 3, main deck, frame 57
3	Top of stack, frame 83
4	Aft starboard gun tub, frame 144
5	Top of hatch 5, main deck, frame 128
6	Top of hatch 2, main deck, frame 40
7	Top of hatch 4, main deck, frame 104
8	Engine room vent, bridge deck, frame 93
9	Forecastle deck, aft of forward mooring station, frame 8

Maximum moisture removal demands on the D/H machines are made when RH of the outside air is of the order of 75% or higher. This level was noted on 19 February 1972. A record of the readings for the entire day is shown in appendix D. RH readings at all sensor locations remained at acceptable levels throughout the day.

Response of the system to the passage of a cold front with attendant decrease in RH of the ambient air on 14 April 1972 is tabulated in appendix E. The incoming pressurized ambient air is comingled with the dehumidified air at hatch 3. Offhand, a

significantly higher RH would be expected in this vicinity than in other areas of the dehumidified air zone. However, operation of the D/H machines and air ducting has been so well integrated that the RH of the air at hatch 3 is only fractionally higher than at other positions.

Observations to date indicate that the RH of the air in the total D/H zone of the ship will continue to be maintained efficiently at the low levels required for minimizing metal corrosion.

The cover has been designed to withstand wind velocities up to 100 knots and a snow load of 7 psf (12 inches of snow). Based on a 25-year return period, the estimated maximum wind velocity at Philadelphia is 61 knots, and in the Norfolk-Portsmouth area is 69 knots.

So far, the highest wind velocity to which the cover has been exposed since it was installed in October 1971 is 46 knots, as noted in appendix F. The cover withstood these gusts without any indication of adverse effects. At no time during the 1971-1972 winter did snow accumulate on the cover to a depth of 12 inches. However, after several minor snow storms it was observed that because of the rounded shape of the cover, the snow tended to slide or blow off the cover as the latter swayed under wind impact.

Successful performance of the topside encapsulation concept is largely dependent on the combined capabilities of the air blowers of the inflation system to maintain the required air pressure, and of the dehumidifiers to maintain approximately 35% relative humidity within the cover. Factors which determine the capacities required of the blowers and dehumidifiers are the total volume of air within the cover, air-leakage rate, and relative humidity and temperature of the outside air. The loss of dehumidified air by leakage should not exceed the combined capabilities of the blowers and dehumidifiers to provide an equivalent volume of dry makeup air within the cover.

Cover material and bonded seams are substantially impermeable with respect to air loss. However, significant air leakage may occur for any of the following reasons:

- Holes or rents in cover.
- Imperfect bond between the sealing flap of the cover and the ship.
- Defective gasketing of quick-closure doors of air locks.
- Defective pressure-relief valves of air locks.
- Inadequate gaskets between flanges of mooring stations and the ship.

- Poorly sealed stuffing tubes.

- Holes or cracks in welding seams of the mooring stations and the ship's hull.

Clearly, many precautions must be taken during preparation of a ship's topsides prior to installation of the cover and during actual fitting of the cover to the topsides in order to restrict air leakage to an acceptable level.

Calculations show that under extremely adverse conditions of high relative humidity and high temperature of external air, maximum air loss must not exceed approximately 350 cfm in order to maintain a 35% relative humidity within the cover. One month after the cover had been installed, the measured air-leakage rate at 2-inches water gage pressure averaged 350 cfm. Eleven months later after a number of previously undetected leaks had been sealed, air-leakage rate had decreased to 288 cfm. These rates are tolerable under extremely adverse conditions. Under more normal conditions of lower relative humidity and lower temperature of ambient air, high air-leakage rates, up to about 600 cfm, could be tolerated.

Detailed information concerning air-leakage tests is given in appendixes G and H, and on page 65 of the final report.[1]

In general, performance of the prototype cover during its first year of operation has been impressive. Relative humidity of the air within the cover and leakage of air have been at levels well within acceptability limits. Operation of the air pressurization and air dehumidification systems has been substantially trouble-free.

Several series of pinhole perforations extending for approximately 1 foot in straight lines in the warp direction of the cover fabric, have developed in the starboard bow and aft starboard gun tub areas. In these locations, the base nylon fabric was 6-ounce basket weave. A tighter woven 8-ounce plain-weave fabric was used for other sections of the cover.

The contractor's comments concerning the pinholes are given in appendix I. The presence of a relatively small number of pinholes is considered to have negligible adverse effects on the performance of the D/H system. However, in future cover procurements, the contractor should be made responsible to develop quality control standards for the coated fabric so that the incidence of pinhole development is minimized.

IMPROVED PRESERVATION PROCEDURES

Bases for maximizing the advantages to be derived from the total concept of ship topside encapsulation were emphasized during presentations made to NAVSHIPS (SHIPS 043 and 00) by representatives

of this laboratory, in August 1971. Optimization of the total concept included extensive revisions of the Inactive Status Technical Manual.[10] The intent of the revisions was to permit equipment aboard a naval ship scheduled for inactivation by the topside encapsulation process, to remain in an "as is" condition to the maximum extent possible and would recognize the following facts:

- Air dehumidified to a relative humidity of approximately 35% by itself is an effective preservation medium.

- The currently used solvent cutback corrosion preventive, as a backup to preserve machinery and related equipment, should be discontinued.

- It should be replaced by more cost-effective methods of preservation using available modern preservative lubricating oils.

Several potential advantages attributable to replacing solvent-cutback corrosion preventive with preservative lubricating oils appear readily achievable.

- Recognized hazards to personnel and equipment associated with the use of solvent-cutback corrosion preventive would be minimized.

- Application and removal of solvent-cutback corrosion preventive is more involved, more time-consuming, and more expensive than for preservative lubricating oils.

- Operational problems, attributable to incomplete removal of solvent-cutback corrosion preventive during ship reactivation, would be eliminated.

- Preservative lubricating oils are wholly compatible with their lubricating oil counterparts.

- Preservative lubricating oils are fully operational lubricants.

- Preservative lubricating oils are less expensive than solvent-cutback corrosion preventive.

During a conference held on 6 March 1972, NAVSHIPS (SHIPS 043) assigned top priority to the development of recommendations for revising the technical manual[10] by minimizing the use of solvent-cutback corrosion preventive for the preservation of below-deck machinery by either the conventional or topside encapsulation methods. Details concerning the recommendations are given in appendix J.

Additional recommendations for revisions of the manual, which incorporate more efficient practices for the topsides of ships

preserved with air-supported structures, are described in appendix K. However, NAVSEC has considered it premature to adopt the latter group of recommendations because of the limited service experience with the prototype installation aboard AK 260 (reference (f)).

COST-EFFECTIVENESS ANALYSIS

Performance of the prototype air-supported structure during the first year since its installation indicates that a service life in excess of 10 years appears attainable, and attests to the technical feasibility of the concept. Its economic feasibility is of comparable significance and has been evaluated in a time-cost analysis.

It was recognized that appreciable developmental and some redundant costs which had been incurred during the prototype installation would not be chargeable to future installations. It also was realized that further reductions in labor, materials, and overall costs could be effected by simplifying cover design as well as ship topside modifications required in order to provide a sound interface between cover and ship, and by utilizing improved preservation procedures.

The analysis disclosed that by using the topside encapsulation procedure, labor savings of approximately 2000 man-days could be achieved over the total inactivation/reactivation cycle. For the reactivation segment alone, savings of nearly 1900 man-days appeared possible. Estimated costs for the topside encapsulation and conventional methods of preservation were similar. Additional cost savings which could be attained by employing the simpler, less time-consuming preservation procedures and with the benefit of experience, appear possible, but at present these are not calculable.

Complete information concerning the cost-effectiveness analysis appears in appendix L.

INSTRUCTION MANUAL

A comprehensive instruction manual, which includes general information and operating and maintenance guidance for the prototype air-supported structure, has been provided by the contractor for use by personnel of INACTSHIPFAC PHILA. Among the topics covered in the manual are the system operational details; scheduled maintenance; troubleshooting; corrective maintenance; lists of parts; cover dismantling procedure; and operating instructions, diagrams, and parts lists for ancillary equipment.

In the event future air-supported structures are installed on other inactivated naval ships, similar instruction manuals should be prepared by individual contractors for use by personnel of cognizant INACTSHIPFACs.

FUTURE INSTALLATIONS

A major advantage of the topside air-supported structure concept of ship preservation is that considerable topside equipment and gear can remain in place within a dehumidified air environment where its deterioration is minimized. By contrast, the conventional method of ship inactivation requires that much topside equipment be disassembled, stowed below decks in a dehumidified air zone, and entered on the ship's current ship's maintenance projects file, the activation check-off list, and stowage plan. Later, during reactivation, this sequence of operations must be reversed. From the viewpoint of labor and time savings, it is evident that the new concept should find maximum applicability to those classes of ships fitted with the most topside machinery and gear which ordinarily would have to be disassembled and stowed below decks during inactivation. As pointed out in discussions with NAVSHIPS (SHIPS 04), naval auxiliary classes represent hull types preferred for topside encapsulation.

From the standpoint of minimizing deterioration of a ship's topside, including deckhouse, other superstructure components, and gear, the new concept also is preferable to the conventional method. In addition to auxiliaries, it appears well suited for wooden-hulled minesweepers (MSO class), where major deterioration of deck planking and portions of the hull above the water line has been observed.

Because of funding and time limitations it has not been possible to make a detailed time-cost analysis for a typical combatant ship, e.g., the DD class. Consequently, the economics of applying topside encapsulation to such classes remains to be evaluated.

For the above reasons, universal implementation of the new concept appears unwarranted at this time. Rather, it should be applied selectively to those ships which are most likely to be returned to active status and which would provide opportunity for exploiting cost-effectiveness advantages, especially in the reactivation phase.

SUMMARY

A novel method of long-term preservation of naval ships has been implemented. It consists of installing an air-supported structure, within which dehumidified air is circulated, aboard the topside of a ship.

Performance of the prototype air-supported structure during its first year of operation has been impressive.

A more efficient backup system of preserving below-deck machinery with preservative lubricating oils in place of solvent-cutback corrosion preventive, is being implemented.

Experience with the prototype installation will provide for the development of improved:

- Concepts for design of:
  - Shipboard air-supported structures.
  - Ship topside modifications required for fitting structures, for future installations.
- Methods for draping and fitting structures for future installations.

In order to implement the new concept to the fullest, a new philosophy of naval ship preservation has been developed. It calls for:

- Minimum removal of topside equipment and gear.
- Elimination of conventional preservation work to the maximum extent possible.

A cost-time analysis, which compares the conventional method of ship preservation with the new concept as applied to naval auxiliaries similar to USS BETELGEUSE (AK 260), has been made.

CONCLUSIONS

Successful performance of the prototype ship topside cover, during the first year of its installation, has confirmed the technical feasibility of the new concept of naval ship preservation.

Preservation of selected naval auxiliaries with air-supported topside structures should result in:

- Significant labor savings, especially during ship reactivation.
- A significant reduction in time to reactivate a ship.

Costs of preserving an auxiliary similar to USS BETELGEUSE (AK 260) by the conventional method and by the new concept appear similar. However, additional cost improvements in implementing the new concept are possible.

The availability of modern, fully operational preservative lubricating oils provides an improved means of preserving machinery of inactive ships.

Improvements in designs of shipboard air-supported structures and ship topside modifications for accommodating these structures can be made.

More efficient methods of draping and fitting air-supported structures on ships' topsides are available.

RECOMMENDATIONS

Implementation of the new concept of ship preservation should be extended selectively to include those classes of naval ships having the best opportunity for payout. This also would include inactive ships specially susceptible to deterioration.

A time-cost analysis comparing the conventional method of ship preservation with the new concept applicable to a combatant ship (e.g., DD class) should be made.

A search for further potential naval applications of air-supported structures should be made and their feasibilities evaluated. For example, these uses could include covers over dry docks, which would serve the dual purpose of facilitating work aboard ships during inclement weather and minimizing local air pollution during major ship sandblasting and coating operations, as well as ground shelters within which small-scale construction jobs could be handled uninterruptedly during foul weather.

FUTURE WORK

Consultation and technical assistance regarding ship topside air-supported structures will be provided as requested by NAVSHIPS (SHIPS 04) and other Navy agencies for further implementation of the new concept.

TECHNICAL REFERENCES

1 - Egan, Robert S., "Final Report, Topside Encapsulation Project, Design Division, Philadelphia Naval Shipyard," NSRDC Rept 28-489 (Oct 1972)

2 - "Air-Supported Enclosure for Ship Topside, Design and Manufacture of," (and amendments thereto) NAVSHIPYD PHILA Solicitation N00151-71-R-0280 (21 Aug 1972)

3 - "Air-Supported Enclosure for Ship Topside; Design and Manufacture of," NRPO PHILA Contr N00140-71-C-0150 (15 Jan 1971)

4 - Sarchin, T. H., and L. L. Goldberg, "Stability and Buoyancy Criteria for U. S. Naval Surface Ships," J. Soc. Naval Architects and Marine Engineers, pp. 418-458 (1962)

5 - "Calking, Compounds, Metal Seam and Wood Seam," Mil Spec MIL-C-18969, Type 2, Class B (6 July 1971)

6 - Maynard, J. T., and P. R. Johnson, Rubber Chem. and Tech., pp. 963-974 (Oct-Nov 1963)

7 - "Paint, Rubber, Rigid, and Air-Supported Radome," Mil Spec MIL-P-9503B (2 Feb 1961)

8 - "Plastic Material, Unicellular (Sheets and Tubes)," Mil Spec MIL-P-15280E, Interim Amendment 1 (SHIPS) (21 Mar 1969)

9 - "Dehumidifiers, Rotary, Desiccant, Electric (For Shipboard Use)," Mil Spec MIL-D-24322 (SHIPS) (2 Feb 1968)
10 - "Readiness and Care of Naval Vessels in the Inactive Status," NAVSHIPS Tech Manual, Ch. 9030 (Sep 1967)

APPENDIX A

SINGLE-WALL AIR-SUPPORTED STRUCTURES SERVICE PERFORMANCE RECORDS

Structure			Company	Location	Service Period years	Comments
Purpose	Composition	Size				
Radome cover	Neoprene-coated nylon painted with Hypalon; noncable reinforced	28-foot diameter	Owen-Knight Corp.	Cambridge, Mass.	13	Condition of cover excellent after 13 years; no refurbishing during 13 years
Telstar radome cover	Dacron-coated with Hypalon; noncable reinforced	210-foot diameter	AT&T	Andover, Me.	10	Condition of cover good after 10 years
Shelters for radomes, etc	Neoprene-coated nylon painted with Hypalon; noncable reinforced	Various	Bone Air Development Center	Over world including Tropics	10+	Hypalon paint excellent protection versus UV radiation; in Tropics likely that more frequent painting with Hypalon be required
Radomes		Various	B. F. Goodrich Co.		20+	Goodrich's Radolon Hypalon paint provides excellent protection against UV radiation; if properly applied to Neoprene, this paint should last longer than 15 years in Tropics
Radomes	Neoprene-coated nylon painted with Hypalon; noncable reinforced	Various	AT&T	Various, including White Sands, N. M. and Eualabin		Hypalon paint an excellent preservative effect in tropics where high level actinic exposure prevails
Radome covers; total of 15	Nylon coated with Neoprene; noncable reinforced	Approximately 25-foot diameter	Nike System Component	Okinawa	11	Withstood 150 mph typhoon winds

AT&T - American Telephone and Telegraph.
UV - Ultraviolet.

APPENDIX B

NSRDC/A LETTER "SHIP TOPSIDE ENCAPSULATION PROGRAM; POST COVER INSTALLATION CONFERENCE"

DEPARTMENT OF THE NAVY

NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

ANNAPOLIS LABORATORY

ANNAPOLIS, MARYLAND 21402

IN REPLY REFER TO

NP/4770 (2841 HEA)
Work Units 1-841-511-A
and 1-841-512-A

19 NOV 1971

From: Officer-in-Charge
To: Commanding Officer, Philadelphia Naval Shipyard

Subj: Ship Topside Encapsulation Program; Post Cover Installation Conference

Encl: (1) Comments and suggestions to expedite future ship topside cover installations

1. Installation of the cover over the topside of AK 260 was accomplished on 19 and 20 October 1971 at NAVSHIPYD PHILA. High broadside wind velocities, up to approximately 20 knots, were experienced on these dates, which created a number of problems when draping the cover over the ship and slowed cover installation past the desired one day period.

2. With the view of improving future cover installations aboard ships, a conference was held on 21 October to solicit comments and suggestions, based on experience with the prototype installation. The conference was attended by the following:

D. McGarvey	Shop 072, NAVSHIPYD PHILA
F. J. Simone	Shop 072, NAVSHIPYD PHILA
L. J. Ciervo	Shop 072, NAVSHIPYD PHILA
R. J. Egan	Design Div., 250.4, NAVSHIPYD PHILA
E. Franciotti	Design Div., 270.1, NAVSHIPYD PHILA
E. Harris	Code 216.3, NAVSHIPYD PHILA
J. Izquinto	Code 216.7, NAVSHIPYD PHILA
W. L. Fowler	BIRDAIR STRUCTURES, INC.
LT. C. A. Kulik, USN	INACTSHIPFAC PHILA
T. Theodorides	INACTSHIPFAC PHILA
A. Winer	NAVSEC 6101E
H. E. Achilles	Code 2841, NAVSHIPRANDCEN ANNALAB
J. W. Cadorette	Code 2852, NAVSHIPRANDCEN ANNALAB
A. L. Waldron	Code 2852, NAVSHIPRANDCEN ANNALAB

3. Specific points which were brought to attention for further consideration are summarized in enclosure (1).

A. Rufolo

A. RUFOLO
By direction

Copy to: (w/encl.)
NAVSHIPS 04
NAVSHIPS 043
NAVSHIPS 03421
NAVSHIPYD PHILA Code 250.4
NAVSHIPYD PHILA Code 270.1
NAVSHIPYD PHILA Shop 72 (3)

29

Copy to: (w/encl.) Contd
NAVSHIPYD PHILA Code 216.3
NAVSHIPYD PHILA Code 216.7
INACTSHIPFAC PHILA
NAVSEC 6101E
BIRDAIR STRUCTURES, INC. (Mr. W. L. Fowler)

30

SHIP TOPSIDE ENCAPSULATION
USS BETELGEUSE (AK 260)
CONFERENCE

NAVSHIPYD PHILA, 21 OCT 1971

Subj: "Comments and Suggestions to Expedite Future Ship Topside Cover Installations"

1. Cady 8000 Unloading Pallets

a. Change dimensions

Consideration should be given to making the pallets wider, proportional to the beam of the specific ship. Mooring between the two pallets should be made more rigid to prevent undesirable relative movements.

b. Unloading of cover

Shape of the unloading pallets should be modified so that the ends extend in a broad arc in order to facilitate draping the cover. Fore and aft tilt of the pallet must be carefully controlled. The cover should be folded on the pallets so that the transverse cables are arranged in the proper position to assure their sequential drop as the cover is draped. This should correct the cable jamming experienced in the case of AK 260. Use of fairleads to assist in controlling drape of cover over ship should be considered.

c. Relative alignment of pallets

After the pallets are raised over the ship, they should be maintained in the same parallel position in which they were maintained when lifted from the dock. Techniques to achieve same should be developed.

d. Number of pallets

Consideration had been given originally to the use of only one pallet in place of the two employed for the AK 260. It was suggested that the possible use of one larger pallet again be reviewed.

2. Cover

a. Outboard of the loading pallets, the cover should be secured to prevent its billowing as it is raised.

b. Possible use of tie downs in the form of bands provided with controlled release of cover folds, should be considered.

c. The sleeves of transverse cables should be reinforced to provide handling points at key locations, such as near the ends of the cables, so that lines to cranes can be attached for mechanized handling as the cover is draped. These points should be faired relative to the cover fabric.

d. Portions of the cover, such as the sealing skirt which may be subject to chafing by the transverse cable at mooring stations when the cover is inflated, should be reinforced or protected.

e. Projections of the superstructure should be covered with hard padding having a smooth surface rather than using the soft conformal padding with a relatively rough surface, as for the AK 260. Bald rubber tires have been suggested. Extent and simplicity of padding should be increased. These changes will allow the cover to slide more readily over padded ship superstructure projections during draping.

f. Index marks should be shown clearly on the inside and outside of the cover to assure proper location of the cover over the ship prior to draping and to facilitate actual draping.

g. Consideration should be given to varying the diameter of the transverse cables in relation to the loads which must be supported at specific locations.

3. Cranes/Rigging

a. The use of powered equipment should be extended to provide maximum possible assistance to handlers aboard the ship. Optimum tie-down points on transverse cables should be selected and correlated with flexibility of machinery.

b. Wind criteria should be re-evaluated.

c. Consideration should be given to the design of more efficient manual equipment for handlers aboard ship who assist in draping the cover.

d. Erection and disassembly of staging is costly. Consideration should be given to minimizing its use. However, retention of staging on the sides of the ship is highly desirable.

e. Complete cover installation equipment requirements should be determined in advance so that the necessary inventory is at hand.

Subj: "Comments and Suggestions to Expedite Future Ship Topside Cover Installations"

4. Preparation/Design

a. Mooring station enclosures

Fabrication and installation of the mooring station enclosures is relatively expensive. The feasibility of eliminating them or replacing them with less costly equivalents should be explored. Perhaps locating mooring bits on the side of the hull may be a preferred alternative. The need for air locks also should be reviewed.

b. Piping/tubing/hoses

Less expensive transfer lines should be utilized. For example, in place of custom welded pipes used as ducts for air transfer, substitute reinforced plastic tubing which is available in various diameters. Uniformity in shape and dimensions of ducts for a specific type service should be sought.

c. Fire protection

Future design should provide for ready access of the emergency fire main from the dock to within the cover.

d. Intervals between transverse cables

The desirability of bonding transverse cables at closer intervals to the cover fabric, especially at the bow and stern, should be checked. This could result in a decrease in diameter and weight for individual cables and would facilitate draping and fastening of cover.

5. Procedures/Cost Reduction*

a. Start of installation

Consideration should be given to optimum choice of where to start and how to start installation.

b. Folding/flaking of cover

Improved means of folding and releasing the cover should be developed.

c. Talc

Generous use should be made of dusting talc to facilitate release of individual folds of cover from pallets.

d. Installation schedule

All efforts should be made to complete cover installation and inflation in one day.

e. Systematization of effort

Better coordination of supervision, communications, team effort, and use of proper tools should be developed.

f. Tensioned guide lines/fairleads

Appropriate use of above should be made to minimize snagging of cover on superstructure projections as cover is draped.

g. Contractor use of ship

The ship should be cleared for one day before cover installation to allow contractor to complete equipment checkout and miscellaneous topside details.

*Some overlap with a few points listed previously.

APPENDIX C

LOW- AND HIGH-PRESSURE BLOWERS
OPERATING CHARACTERISTICS

	Low Pressure	High Pressure
Supplier's* Model No.	BL 445	BI 270
HP	2	3
RPM	1080	2900
Motor, open, dripproof	3 phase, 460 volt 1755 rpm	60 cycle 1755 rpm
Belt Drive	Belt A51	Belt A38
Blower performance, inches water gage		
0	7000 cfm	4000 cfm
2.1	0	-
6.0	-	0

*Supplier - Buffalo Forge Co.

APPENDIX D

RELATIVE HUMIDITY AND TEMPERATURE WITHIN AIR-SUPPORTED STRUCTURE ABOARD USS BETELGEUSE (AK 260) 19 FEBRUARY 1972

Time hr	Sensor Location															
	Outboard Mooring Station (Ambient Air)		Top of Hatch 3 Main Deck		Top of Stack		Aft, Starboard Gun Tub		Top of Hatch 5 Main Deck		Top of Hatch 2 Main Deck		Engine Room Vent Bridge Deck		Forcastle Deck Aft of Forward Mooring Station	
	RH %	Temp °F	RH %	Temp °F	RH %	Temp °F	RH %	Temp °F	RH %	Temp °F	RH %	Temp °F	RH %	Temp °F	RH %	Temp °F
0100	69	49.5	36	38	34	36.5	34	35.5	34	35.5	27	35.5	28	36.5	32	35
0200	67	47.5	36	38	35	35.5	34	35.5	34	35.5	28	35.5	29	35.5	33	35
0300	65	46	37	37	35	35.5	35	35	35	35.5	28	35	29	35.5	33	34
0400	68	46	38	38	38	38	35	35	35	35.5	28	35	29	35.5	33	34
0500	68	46	37	38	36	35.5	36	35.5	35	35.5	28	35	30	35.5	34	32.5
0600	70	46.5	36	37	35	35	35	35	35	35.5	26	34	29	35	34	32.5
0700	72	46	36	37	35	34	35	34	35	35	28	34	29	34	33	32
0800	75	48	36	36.5	35	34	34	34	34	34	27	33.5	29	34	33	32
0900	76	48	36	37	34	34	34	33.5	34	34	27	34	29	34	33	32.5
1000	76	49	36	37	34	34	34	34	34	34	26	34	28	34	33	33.5
1100	77	49.5	36	37	34	35.5	34	34	34	34	26	34	28	35	32	33.5
1200	74	48	36	37	34	35	34	34	33	35	26	34	28	35	32	33.5
1300	76	46.5	36	37	34	34	34	34	33	34	27	34	28	34	32	32.5
1400	74	45.5	37	37	34	34	34	35.5	33	34	28	34	28	34	33	32
1500	73	45	36	37	34	34	34	34	33	34	28	34	28	34	33	32
1600	70	45.5	36	36.5	34	34	34	33.5	34	34	29	32.5	28	34	33	32
1700	67	45	36	36.5	34	34	34	33.5	34	33.5	28	33.5	28	34	33	32
1800	67	44	36	36.5	34	33.5	34	33.5	34	33.5	28	33.5	28	33.5	33	32
1900	72	45	36	36.5	34	33.5	35	33.5	34	33.5	28	33.5	29	33.5	33	32
2000	75	45	36	36.5	34	32.5	34	32.5	34	32.5	28	33.5	29	34	33	32
2100	61	45	36	36.5	34	33.5	34	33.5	34	33.5	28	33.5	28	34	33	32
2200	51	41	35	35.5	34	32.5	34	32.5	34	32.5	28	32.5	28	33.5	33	32
2300	48	39	35	35	34	32.5	34	32.5	34	32.5	28	32.5	28	33.5	33	31.5
2400	59	41.5	35	35	34	32.5	34	32.5	34	32.5	28	32.5	28	33.5	33	31.5

Temp - Temperature.

Notes: 1. RH at all sensor locations is at acceptable levels.
2. Temperatures are substantially the same at all sensor locations.
3. Under prevailing conditions, the above data indicate a well-designed air circulation throughout the dehumidified air zone.
4. In a letter from Naval Weather Service Detachment, Ashville, North Carolina, dated 28 September 1971, the return period of weather severity is listed as 25 years.

APPENDIX E

RELATIVE HUMIDITY AND TEMPERATURE WITHIN AIR-SUPPORTED STRUCTURE ABOARD USS BETELGEUSE (AK 260) 14 APRIL 1972

Time hr	Sensor Location																	
	Outboard Mooring Station (Ambient Air)		Top of Hatch 3 Main Deck		Top of Stack		Aft. Starboard Gun Tub		Top of Hatch 5 Main Deck		Top of Hatch 2 Main Deck		Top of Hatch 1 Main Deck		Engine Room Vent Bridge Deck		Forecastle Deck Aft of Forward Mooring Station	
	RH %	Temp °F	RH %	Temp °F	RH %	Temp °F	RH %	Temp °F	RH %	Temp °F	RH %	Temp °F	RH %	Temp °F	RH %	Temp °F	RH %	Temp °F
0100	84	70	41	51	39	50	35	51	29	51	29	50	37	46	38	50	38	54
0200	83	70	41	51	38	51	35	51	39	51	29	50	36	46	38	50	36	54
0300	84	70	42	52	39	51	36	51	39	51	29	50	35	47	38	50	36	54
0400	86	72	42	52	38	51	36	51	38	51	29	50	35	47	38	50	38	54
0500	87	73	42	52	39	51	38	51	37	51	29	50	35	46	38	50	38	54
0600	86	76	42	52	38	51	37	51	37	51	27	50	35	47	37	51	38	56
0700	76	74	42	52	39	51	37	51	37	51	27	50	35	47	38	50	37	56
0800	57	67	42	51	39	50	37	50	37	50	27	50	35	46	36	50	37	51
0900	47	58	37	52	32	56	37	52	37	51	26	51	33	47	34	53	36	61
1000	40	55	35	54	29	59	34	55	36	51	25	53	31	46	32	56	35	61
1100	37	53	36	53	28	59	34	56	36	52	23	55	30	46	32	56	33	62
1200	37	53	35	55	28	60	33	56	34	53	23	54	29	46	30	57	33	63
1300	36	53	33	56	26	65	32	58	34	53	23	57	28	50	29	58	32	70
1400	35	54	33	58	24	70	33	59	32	55	22	58	28	51	28	59	29	72
1500	35	55	33	58	25	68.5	32	59	32	55	22	60	28	52	28	60	28	74
1600	34	56	32	60	22	79.5	32	61	34	56	22	59	28	52	28	60	31	76
1700	34	56	32	60	23	73	32	60	34	57	26	60	30	53	28	59	31	80
1800	33	56	32	62	25	72	32	60	34	56	26	60	31	53	28	59	28	78
1900	33	59	32	62	27	67	32	60	35	56	26	60	31	54	28	59	28	78
2000	34	58	34	59	32	60	32	60.4	34	56	28	59	32	53	32	57	32	71
2100	34	56	35	58	33	58	34	56	35	56	32	57	33	51	33	56	34	66
2200	35	55	36	56	35	56	35	56	35	56	32	56	33	51	34	56	35	66
2300	35	53	37	55	37	53	36	55	36	54	29	54	34	50	36	54	36	61
2400	36	52	38	54	38	53	37	53	36	55	27	53	32	50	37	53	37	59

Temp - Temperature.

APPENDIX F

NSRDC/A LETTER "SHIP TOPSIDE ENCAPSULATION; PERFORMANCE OF COVER ABOARD USS BETELGEUSE (AK 260)"

Annapolis Laboratory
2841:HEA
4770
Work Unit 2841 512
4 Feb 1972

From: Commander, Naval Ship Research and Development Center
To: Commander, Naval Ship Systems Command (NAVSHIPS 043)

Subj: Ship Topside Encapsulation; Performance of Cover Aboard BETELGEUSE (AK-260)

1. The cover aboard the topside of AK-260 has been designed to withstand wind velocities up to 100 knots. The highest wind velocity to which the cover has been exposed since its installation occurred on 25 January 1972, when gusts up to 46 knots were recorded. Performance of the cover was observed at that date by Mr. R. S. Egan, Code 250.4, Design Division, NAVSHIPYD PHILA, and was reported during a telephone discussion held with Dr. H. E. Achilles, of this laboratory, on 28 January 1972.

2. AK-260 is berthed in a general north-south direction with the bow headed south along the east side of Pier C at the Philadelphia Naval Base. During the period of observation prevailing direction of the wind was from the west with intermittent shifts to the northwest. Some degree of protection from the westerly winds was afforded by CHANDELEUR (AV 10) which is berthed along the western side of Pier C.

3. Under the wind impact pressure the windward side of the cover did not move bodily as a unit. Instead a slow wave movement developed near the stern and traveled slowly forward from one corrugation of the cover to the next. Magnitude of the cover deflections was of the order of two to three feet. There was no apparent uplift of the cover at the profile height, nor was any movement evident at the extreme forward and after ends of the cover, which have enhanced stiffness. At no time did it appear that the cover made contact with any interior topside superstructure projections.

A. RUFOLO
By direction

Copy to:
NAVSHIPS 03421
NAVSEC 6101E
NAVSHIPYD PHILA Code 250
NAVSHIPYD PHILA 250.4

Report 28-550

APPENDIX G

NSRDC/A LETTER "SHIP TOPSIDE ENCAPSULATION (AK 260); ATMOSPHERE CONTROL SYSTEM AND AIR LEAKAGE TEST"

DEPARTMENT OF THE NAVY
NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER
ANNAPOLIS LABORATORY
ANNAPOLIS, MARYLAND 21402

IN REPLY REFER TO
NP/4770 (2841 HEA)
Work Units 1-2841-511-A
and 1-2841-512-A

7 JAN 1972

From: Officer-in-Charge
To: Commander, Philadelphia Naval Shipyard (Code 260.3.1)

Subj: Ship Topside Encapsulation (AK-260); Atmosphere Control System and Air Leakage Tests

Ref: (a) Type 1 Technical Manual for Rotary Type Desiccant Dehumidifiers, Navy Size 55-505, NAVSHIPS 0938-039-7010, 15 Jan 1970
(b) Carrier Air Conditioning Company, "Handbook for Air Conditioning System Design," pp. 1-14, McGraw Hill, N.Y., 1965
(c) National Weather Records Center, Environmental Data Service, Environmental Science Services Administration," Working Paper for the Revision of MIL-STD-210A to MIL-STD-210B, U. S. Navy, p. 17, of Feb 1970
(d) NAVSHIPYD PHILA, Solicitation N00151-71-R-0280, "Air Supported Enclosure for Ship Topside, Design and Manufacture of," of 21 Aug 1970, and subsequent amendments thereto
(e) Technical Proposal, BIRDAIR STRUCTURES, INC., of 23 Sep 1970 and subsequent revisions thereto
(f) Material Inspection and Receiving Report, NRPO Contract N00140-71-C-0150, 23 Nov 1971

Encl: (1) Air Leakage Flow Rate Calculations Ship Topside Encapsulation for AK-260 (2 sheets)

1. The atmosphere control system within the air-supported structure aboard AK-260 consists of two sub-systems, as follows:

a. Air Pressurization Sub-System: Blowers of the air pressurization sub-system draw into the structure air which is maintained automatically at the required pressure. There are two low pressure and two high pressure blowers. One of each rating is intended for standby service. For wind velocities below 40 knots, internal air pressure is maintained at 2 inches water gauge. When wind velocity exceeds 40 knots, a high pressure blower cuts in automatically to increase the pressure to 6 inches water gauge so that the structure can withstand the greater impact pressure caused by high velocity winds.

b. Air Dehumidification Sub-System: The volume of air aboard AK-260 which must be processed to a 30-35% relative humidity is approximately 1,700,000 cubic feet (CF). The hull interior accounts for 740,000 CF and the enclosed topside totals some 960,000 CF. Long term experience with ship preservation indicated that two size 55-505 rotary dehumidifiers, as described in reference (a), were required to handle a hull interior of

about 74[illegible]00 CF. NAVSHIPYD PHILA Code 260.3, Air Conditioning and Ventilation Branch recommended the installation of three additional dehumidifiers in order to handle the additional topside volume of 960,000 CF. Each of the five units has an air flow capacity of 500 cubic feet per minute (CFM), and by means of sensors maintains a relative humidity (RH) at 30 to 35%. Based on long term experience the Reserve Fleet expects that once an RH of 30-35% has been attained, each dehumidifier in effect will operate only 50% of the time, or at half of its nominal capacity. Each unit has a minimum rated water absorption capacity of 6.5 pounds per hour at 70°F.

2. The maximum demand which the dehumidifiers would have to meet in the Philadelphia area occurs only occasionally during the summer months when the air temperature and relative humidity are high. Based on climatic information included in reference (b), NAVSHIPYD PHILA Code 260.3.1, Air Conditioning and Ventilation Branch, advised that under such extremely unfavorable climatic conditions, air entering the enclosure aboard AK-260 would have a dry bulb temperature of 95°F and a relative humidity of 78 percent. After entry within the structure temperature of the air would be reduced to 70°F dry bulb and its relative humidity would be decreased to 35 percent. Under these unusual conditions, maximum air flow coupled with rated water absorption capacity of the dehumidifiers must not exceed 342 CFM in order to maintain the 35% RH. Calculations confirming those made by NAVSHIPYD PHILA Code 260.3.1 are shown in enclosure (1).

3. Under less demanding climatic conditions prevailing for the major portion of a year, that is, lower air temperature and RH, the limiting effect of water absorption capacity of a dehumidifier on its air flow capacity would be eased, and air leakage rates greater than 342 CFM could be tolerated.

4. Technical success of the topside encapsulation concept depends on the ability of the air blowers to maintain required internal air pressure of 2 inches water gauge and of the dehumidifiers to maintain a 30-35% RH. Factors which determine the capacities needed in these two sub-systems are total volume of air (1,700,000 CF), air leakage rate, and outside air temperature and RH.

5. Climatological records identified in reference (c) indicate that wind velocities below 40 knots would be expected for more than 97 percent of the time at Philadelphia. Thus 2 inches water gauge air pressure within the cover aboard AK-260 can be regarded as the norm or reference pressure at which air leakage rates should be measured to assess cover sealing effectiveness.

6. An air leakage rate of 20 CFM was selected as a target in reference (d) as an incentive for prospective bidders to provide as air-tight an enclosure as possible. Admittedly, this level was rather optimistic and it was acknowledged that in practice a somewhat higher rate could be considered acceptable. BIRDAIR STRUCTURES, INC., the eventual contractor, was the only bidder who signified his intention to attain this target level, as described in reference (e).

7. A series of tests was made aboard the encapsulated AK-260 at NAVSHIPYD PHILA on 23 November 1971 to determine if the air leakage rate from the structure was within limits acceptable to the Navy. An inclined manometer was used by BIRDAIR and air calibrated anemometers were used by NAVSHIPYD PHILA Code 260.6.1. The inclined manometer in this case had an estimated accuracy of perhaps $\pm$ 5 percent and it generally is considered more reliable than the anemometer.

8. Air leakage rate calculations by BIRDAIR were based on the following equation.

$$Q = 1096.5\ CA\sqrt{\frac{P}{\rho}}$$

Where Q = CFM air
C = Coefficient of discharge, 0.601
A = Orifice area in square feet
P = Static air pressure in inches water gauge
ρ = Weight of air, pound per cubic foot

Air Temperature	35°F
Wind Velocity	4 - 18 knots

Results of tests at 2 inches water gauge pressure are shown in Table 1.

Table 1

Air Pressure Inches Water Gauge	Air Leakage Rate, CFM	
	BIRDAIR	NAVSHIPYD PHILA
2.0	325	No simultaneous test made
2.0	350	385
1.8	390	450

Shipyard personnel working aboard ship occasionally passed through air locks of mooring station enclosures, which unavoidably increased air leakage, and this was included in the above measured values.

9. Efforts were made to obtain accurate measurements of leakage rates higher than 2 inches water gauge, but this was not possible. With the port air inlet blanked and size of the starboard air inlet restricted to an orifice with a 6 inch diameter, the high pressure blowers were unable to draw in sufficient air to compensate for air leakage and could not maintain an equilibrium 6 inch internal pressure. As an expedient, the port inlet was opened so that 6 inches internal pressure could be attained by the blowers. Then the port air inlet was blanked and a series of readings was taken as the internal air pressure gradually decreased in order to obtain an approximate air leakage rate. Results are shown in Table 2.

Table 2

Air Pressure Inches Water Gauge		Air Leakage Rate, CFM	
At Start of Test	At End of Test	BIRDAIR	NAVSHIPYD PHILA
6.2	6.0	350	405
5.9	5.8	400	460
5.6	5.45	430	490
5.45	5.3	480	570

10. An additional leakage test was made with the two high pressure and two low pressure blowers on line and with the port air inlet blanked. The object was to let the internal pressure seek its own equilibrium level. At the observed equilibrium pressure of 4.4 inches an air leakage rate of 640 CFM was recorded by BIRDAIR and 695 CFM by NAVSHIPYD PHILA. The measurements indicated the magnitude of the increased air leakage rate which could be expected at higher pressure levels. In all cases air leakage rates measured with the anemometer were higher than with the inclined manometer. Reason for the difference has not been explained.

11. The measured air leakage rate at 2 inches water gauge averaged 350 CFM. This leakage rate can be tolerated since the air control system would be expected to maintain the 55% RH under even the most adverse climatic conditions, as noted earlier in paragraph 3. Actually, a leakage rate far in excess (possibly up to 600 CFM) could be tolerated under normal atmospheric conditions.

12. Response of the air pressurization system to an increase in wind velocity from less than 40 knots to 40 knots and higher is quite rapid. When actuated manually to duplicate the increase, the control system raised

the internal air pressure from 2 to 6 inches water gauge in 10 minutes. Conversely, when the high pressure blowers were cut out and the low pressure blower was cut in, the pressure dropped from 6 to 5 inches water gauge in three minutes. Pressure drop in this case understandably is dependent on air leakage.

13. In view of the test results it was recommended by NAVSHIPYD PHILA Code 260.3.1 and NAVSHIPRANDCEN ANNALAB that the cover be accepted by the Navy. Formal product quality assurance and acceptance by the Navy is documented in reference (f).

14. It is expected that some of the small leaks still remaining between the cover and hull will be located during shipboard inspections by NAVSHIPRANDCEN ANNALAB personnel. These leaks will be sealed and a decreased air leakage rate should be achieved.

15. INACTSHIPFAC PHILA has advised that it usually requires about 90 days for the interior of a ship's hull to dry after the air dehumidification system begins operation. A system of temperature and RH sensors connected for continuous automatic read-out has been installed aboard AK-260. The measurements made to date have already provided a good indication that the air within the encapsulated ship will be reliably maintained at the desired equilibrium of 30-35% RH. Measurements will be made during high temperature and high humidity periods to confirm performance at these more demanding climatic conditions.

A. Engelb
A. ENGELB
By direction

Copy to:
NAVSHIPS 03421
NAVSHIPS 04
NAVSHIPS 043
NAVSHIPS 0431
NAVSEC 6101E
INACTSHIPFAC PHILA
NAVSHIPYD PHILA Code 216
NAVSHIPYD PHILA Code 250.4
NAVSHIPYD PHILA Code 260.3.1

SHIP TOPSIDE ENCAPSULATION (AK-260)

AIR LEAKAGE FLOW RATE CALCULATIONS

Note: Calculations were based on the following unusually adverse ambient air conditions:

	Ambient Inlet Air	Air Within Cover
Temperature, dry bulb	95	70
Relative humidity (R/H), %	78	35

o

Inlet air at 95°F
at 100% R/H, mass of water vapor = 17.32 grains/CF
and 78% R/H, mass of water vaper = 13.51 grains/CF

Air within cover at 70°F
at 100% R/H, mass of water vapor = 8.064 grains/CF
and 35% R/H, mass of water vapor = 2.822 grains/CF

And one CF air at 95°F is
equivalent to $1.0 \times \frac{530}{555}$ or 0.964 CF at 70°F

Net reduction in mass of water vaper
per CF at 95°F reduced to 70°F is 13.51 grains
less 2.82 grains
or 10.69 grains

Maximum air flow capacity, one dehumidifier = 500 CFM
Maximum air flow capacity, five dehumidifiers
at 50% operating factor = 1,250 CFM

Minimum water absorption capacity
at 70°F/dehumidifier = 6.5 lb./hour
or 45,500 grains/hour
or 758 grains/minute

and, minimum weight of water which can be
removed by five dehumidifiers = 3,790 grains/minute

Maximum air flow rate/5 humidifiers consistent with minimum water absorption capacity (taking into account each CF air at 95°F is equivalent to 0.964 CF at 70°F) is:

$$\frac{\frac{3{,}790 \text{ grains water}}{\text{minute}}}{\frac{10.69 \text{ grains water}}{0.964 \text{ CF air}}} \quad \text{or 342 CFM}$$

This means that under the unusually adverse ambient atmospheric conditions or high temperature, 95°F, and high relative humidity, 78%, tolerable air leakage also is 342 CFM

At lower ambient air temperatures and relative humidities a proportionately higher air leakage rate could be tolerated.

APPENDIX H

NSRDC/A LETTER "SHIP TOPSIDE ENCAPSULATION (AK 260); AIR LEAKAGE TESTS, RESULTS OF"

DEPARTMENT OF THE NAVY
NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER
HEADQUARTERS
BETHESDA, MARYLAND 20034

ANNAPOLIS LABORATORY
ANNAPOLIS, MD 21402
CARDEROCK LABORATORY
BETHESDA, MD 20034

IN REPLY REFER TO:
Annapolis Laboratory
2841:HEA
4770
Work Unit 2841-512
7 NOV 1972

From: Commander, Naval Ship Research and Development Center
To: Commander, Naval Ship Systems Command (NAVSHIPS 043)

Subj: Ship Topside Encapsulation Project (AK-260); Air Leakage Test, results of

Ref: (a) NSRDC ltr NP/4770 (2841:HEA) Work Units 1-2841-511-A and 1-2841-512-A, "Ship Topside Encapsulation (AK-260); Atmosphere Control System and Air Leakage Tests," of 7 Jan 1972
(b) NSRDC ltr Annapolis Laboratory 2841:HEA 4770 Work Unit 2841-512, "Ship Topside Encapsulation Project (AK-260) Air Leakage Test, request for," of 6 Oct 1972

Encl: (1) USS BETELGEUSE (AK-260), Air Leakage Tests

1. Tests made aboard USS BETELGEUSE (AK-260) on 23 November 1971, one month after the topside cover had been installed, indicated that the rate of air leakage from within the cover was within limits acceptable to the Navy, as described in reference (a). A second series of tests to check the air-tightness of the cover after one year's operation appeared timely and was requested in reference (b).

2. The current tests were made on 26 October 1972 by personnel of the Design Division, NAVSHIPYD PHILA using a calibrated anemometer. The port air inlet was sealed shut and a 12 inch diameter orifice was superimposed on the starboard air inlet. One low pressure blower operated continuously throughout the tests, and air pressure within the cover was held at a constant 2.2 inches water gauge. Passage by personnel through the air lock was not permitted prior to or during the tests so that the system could attain and maintain equilibrium. Results are tabulated in enclosure (1).

3. Current results are compared below with those obtained originally with the same type test instrument.

Date of Tests	Air Leakage Rate CFM
23 Nov 1971	385
26 Oct 1972	288

Annapolis Laboratory
2841:HEA
4770
Work Unit 2841-512

4. The significantly lower air leakage rate observed in the current tests is attributable to at least two factors. Since December 1971 personnel of INACTSHIPFAC PHILA have eliminated a number of leaks which had not been located previously. Also during the original tests shipyard personnel working aboard ship occasionally passed through air locks of mooring station enclosures, which unavoidably increased air leakage. In the current tests passage through the locks was not permitted. In addition, it is possible that during the past 11 months the slightly higher pressure of the air within the cover has seated the sealing flap of the cover more firmly against the ship's hull and has effected a tighter closure.

5. Air leakage could be reduced even further by patching two small series of pinhole perforations extending in a straight line along the warp direction of the cover fabric. These are located on the starboard side, viz:

a. Bow, at about frame 20, between No. 2 and No. 3 transverse cables, 9 panels up from bottom.

b. Above aft gun tub, 8 panels up.

It is recommended that these perforations be patched before the onset of winter weather and that a coat of Hypalon paint be applied on the outside of the patched area.

6. While standing inside the air locks of the two amidships mooring station enclosures, observers in the current tests could hear the hiss of air passing through small leaks into the lock. Elimination of these leaks would help decrease the load on the dehumidification machines. However, this does not appear critical, because the machines now are operating at less than 50 percent of the time which is within requirements of practices observed by INACTSHIPFAC.

7. Results obtained with the prototype installation indicate that leakage of air from an air-supported structure sealed to the topsides of a ship can be maintained readily within limits acceptable to the Navy and that the air within the structure can be held at the desired low relative humidity in order to minimize corrosion of topside components.

A. RUFOLO
By direction

Copy to:
NAVSHIPS 03421
NAVSHIPS 043
NAVSHIPS 0431
NAVSEC 6101E
NAVSHIPYD PHILA Code 250.2
NAVSHIPYD PHILA Code 260.3
INACTSHIPFAC PHILA

Annapolis Laboratory
2841:HEA
4770
Work Unit 2841-512

USS BETELGEUSE (AK-260)
AIR LEAKAGE TESTS

Date of Tests	26 Oct 1972
Test Equipment	Calibrated Anemometer (Taylor Instrument Co.)
Location of Anemometer	Continuous Scan Over Orifice During Test
Orifice Diameter	12 Inches
Area	0.785 sq. ft.
Air Pressure Within Cover	2.2 Inches water gauge
Test Length	60 Seconds

Time Hours	Air Temp of	Wind Velocity Knots	Air Velocity ft/min	Air Velocity CFM
1130	50	0-8	415	326
1134	50	0-8	400	314
Start	58	0-2	400	314
1320	58	0-2	385	302
	58	0-2	355	379
	58	0-2	325	255
	58	0-2	325	255
End				
1340	58	0-2	330	259
Average	-	-	367	288

Observers			
	J. Jones	Code 269.3	NAVSHIPYD
	F. Pappas	Code 260.5	NAVSHIPYD
	E. Ottavio	Code 260.5	PHILA
	H.E. Achilles	Code 2841	NSRDC

Encl. (1) to Annapolis Lab ltr
2841:HEA
4770

APPENDIX I

BIRDAIR STRUCTURE INCORPORATED LETTER

BIRDAIR STRUCTURES, INC.
AIR SUPPORTED STRUCTURES

July 10, 1972

Dr. H. E. Achilles
Code 2841
Naval Ship Research & Development Center
Annapolis, Maryland 21402

Dear Harold:

This letter confirms our discussions of last Friday regarding pinhole porosity in the shipcover envelope. This porosity became evident to your personnel when lines of light approximately 12" long in the warp direction appeared in the skin in several areas on the end sections.

I have discussed this at length with Walter Bird and we do not believe that this is a serious problem as the defect itself is thought to be due to either one or both of the following conditions:

1. A skip or streak, resulting in a thinner cross section in the warp direction (direction of processing). This would result in a thin coating in this area which could result in some breaks when put under load.

2. A small fold or crease in the fabric which would result in excessive crimp or local distortion of the fill yarns, which was covered by the coating and was not apparent during inspection. When load was applied across this area, after installation, the crimped yarns would straighten out, resulting in a higher than normal stretch along the fold. This stretch could cause small breaks in the coating that would then appear as a line when viewed against the bright sky.

It is most likely that the problem is due to the latter condition. Small creases or excessive distortion of the fill yarn can occur as it is difficult to tension the fabric out in the fill direction during coating. As you may recall, the end sections of the enclosure were fabricated from the 6 oz., 2 x 2 basket weave material which proved to be more difficult to coat. Consequently, we switched to an 8.5 oz. plain weave nylon. Because of its tighter construction, this material was easier to coat and we obtained a higher percentage of quality goods. This later material was used in the center sections of the envelope where no problem has been reported.

Based on the above, we believe the problem being encountered is due to small imperfections in the 6 oz. coated fabric used in the end sections which were not picked up in either our vendor's or our own inspection. To help avoid such problems in the future, we believe a tighter weave fabric, such as was used on the center sections, should be specified. This type of defect should also be spelled out more fully so that the supplier could be held responsible for developing methods to better control this condition.

We believe that by patching the areas you have done the best possible repair; however, we do not believe that the envelope is in any danger as a result of this porosity as the break in the coating would not adversely affect the strength and as loads in the fill direction, which would be across the break, are very low. It is anticipated that any areas where this condition exists will become more evident as a result of continuous exposure, particularly during the hot summer months, and suggest that repairs be postponed until late summer or early fall so that all necessary repairs could be made simultaneously with minimum trouble and expense. Once these initial repairs are made, it is not likely that this condition would show up agai- to any great extent.

Please advise if you require any further information.

Very truly yours,

John E. Bernacki,
Materials Engineer

bts

APPENDIX J

NSRDC/A LETTER "SHIP TOPSIDE ENCAPSULATION PROGRAM (AK 260); REVISION OF NAVAL SHIPS TECHNICAL MANUAL, CHAPTER 9030, READINESS AND CARE OF VESSELS IN INACTIVE STATUS; BELOW DECKS EQUIPMENT"

DEPARTMENT OF THE NAVY
NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER
HEADQUARTERS
BETHESDA, MARYLAND 20034

ANNAPOLIS LABORATORY
ANNAPOLIS, MD 21402
CARDEROCK LABORATORY
BETHESDA, MD 20034

IN REPLY REFER TO:
Annapolis Laboratory
2841:HEA
4770
Work Unit 2841-512

9 JUN 1972

From: Commander, Naval Ship Research and Development Center
To: Commander, Naval Ship Systems Command (NAVSHIPS 045)

Subj: Ship Topside Encapsulation Program (AE-260); Revision of Naval Ships Technical Manual, Chapter 9030, "Readiness and Care of Vessels in Inactive Status," below decks equipment

Ref: (a) Naval Ships Technical Manual, Chapter 9030, "Readiness and Care of Vessels in Inactive Sta
(b) Military Specification MIL-C-16173, "Solvent Cutback Cold-Application Corrosion Preventive"
(c) Naval Ship Research and Development Center Annapolis Laboratory Report S-387 of 15 May 1970, "Low Temperature Vapor Space Corrosion Inhibited Steam Turbine Oil, Evaluation of"
(d) Naval Ship Research and Development Center, Annapolis Laboratory Report S-559 of 30 October 1970, "Low Temperature, Vapor Space Corrosion Inhibited Steam Turbine Oil; Evaluation of"
(e) Military Specification MIL-L-21260, "Lubricating Oil, Internal Combustion Engine, Preservative"
(f) Naval Ships Technical Manual, Chapter 9412, "Diesel Engines"

Encl: (1) Recommended Revisions for NavalShips Technical Manual, Chapter 9030, "Readiness and Care of Vessels in Inactive Service," Below Decks Equipment (8 sheets)
(2) Recommended Revisions for Naval Ships Technical Manual, Chapter 9412, "Diesel Engines," Below Decks Equipment (2 sheets)

1. Bases for maximizing the potential of the total concept of ship topside encapsulation were emphasized during presentations made in August 1971 before NAVSHIPS 045 and NAVSHIPS 00 by representatives of the Naval Ship Research and Development Center, Annapolis Laboratory. The total concept included extensive revisions of reference (a). Intent of the revisions would be to allow equipment aboard a naval ship scheduled for inactivation by the encapsulation process, to remain in an "as is" condition to the maximum extent.

2. Allowing a ship to remain essentially in an "as is" condition would accept the facts that:

a. Air dehumidified to a relative humidity of 30 to 35 percent is by itself an effective preservation medium.

b. The complicated and relatively costly back-up solvent cutback corrosion preventive system of equipment preservation should be replaced.

c. Modern and more cost-effective preservation methods are available and should be used to maintain the required preservation back-up system.

3. During a conference held on 6 March 1972, NAVSHIPS 045 established revised priorities for several phases of the subject program. Top priority was assigned to developing recommendations for revising reference (a) by minimizing the use of solvent cutback corrosion preventive (identified in reference (b)) for preservation of below decks machinery and related equipment by either conventional or topside encapsulation methods. This phase of the program is the subject of the present communication.

4. Examples of minimizing the use of solvent cutback corrosion preventive are as follows.

a. An improved method of preserving turbine oil lubricating systems including purifiers would entail the use of Vapor Space Corrosion Inhibiting Steam Turbine Oil which was developed at this Center as indicated in references (c) and (d). A proposed Military Specification for the product, "Lubricating Oil, Steam Turbine, Vapor Space Inhibited," (VSI2190TEP) has been circularized by NAVSEC throughout industry for comment. The comments are being incorporated into a final draft of the specification which is to be submitted for approval to the Naval Ship Specification Review Board. Two commercial sources of supply of the product already are available.

b. Use of a preservative lubricating oil identified in reference (e) should be expanded to include its application to moderate speed as well as to high speed diesel engines, and also to other lubricating oil systems of below decks equipment such as pumps and compressors, where the application of solvent cutback corrosion preventive should be discontinued.

5. Significant advantages would be realized by using proven preservative lubricants.

a. Application, and particularly removal, of this class of products is simpler and less costly than for solvent cutback corrosion preventives.

b. Recognized hazards to personnel and equipment associated with the application of solvent cutback corrosion preventive would be eliminated. Handling preservative lubricating oils involves minimal hazards.

c. Unit costs of VSI2190TEP and preservative lubricating oils are approximately one-half that of solvent cutback corrosion preventives.

d. Preservative lubricating oils are fully operational lubricants. If a ship were reactivated, the lubricating oil systems of equipment would be fully operational, which could be significant in a national emergency.

e. The individual preservative lubricating oils are readily drained from lubricating oil systems. Traces of the products remaining in systems are wholly compatible with their operating lubricating oil counterparts.

f. Operational problems attributable to incomplete removal of solvent cutback corrosion preventives from lubricating oil systems during ship reactivation would be eliminated.

6. Recommendations and comments regarding revision of reference (a) are listed in enclosure (1). Individual items are identified by manual page and paragraph numbers, and by paragraph titles. Parallel recommendations and comments for diesel engines are shown in enclosure (2), and apply only to Section VII, "Corrosion Prevention," of reference (f).

7. It is likely that even more efficient methods to preserve machinery of naval ships can be developed. For example, the use of volatile corrosion inhibitors (VCI) would offer one approach. Packages of VCI could be placed within machinery units. The controlled release of corrosion inhibiting vapors over extended periods would be expected to assure excellent preservation of equipment. A laboratory program to investigate the applicability of VCI for this purpose would seem warranted.

E. Escoto
By direction

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NAVAL SHIPS TECHNICAL MANUAL

CHAPTER 9030

READINESS AND CARE OF VESSELS IN INACTIVE SERVICE

RECOMMENDED REVISIONS FOR BELOW DECK EQUIPMENT

Page 4, Par. 24.6C - INACTIVATION (PHASE BRAVO).

Add sentence:

"Use of solvent cutback corrosion preventive for interior corrodible surfaces exposed to dehumidified air should be discontinued."

Page 33, Par. 155.2 - REMOVAL (OF SOLVENT CUTBACK, CORROSION PREVENTIVE).

Retain paragraph in order to provide instruction for ships which have been preserved with solvent cutback corrosion preventive.

Page 36, Par. 160.2 - APPLICABLE GRADE.

1. Add new first sentence as for Par. 24.6C above.
2. Delete sentence:

"Grade 2 only shall be used for flushing through lubrication systems."

3. Delete words:

"---interior and---," from current first sentence.

Page 36, Par. 161 - APPLICATION TO PIPING AND GEARS.

Use of solvent cutback corrosion preventive for this equipment should be discontinued. It should be replaced by Vapor Space Inhibited Steam Turbine Oil (VSI2190TEP) or by MIL-L-21260, dependent on operational lubricants used in individual units. Precautions must be observed to ensure that all internal surfaces of components are wet initially by the preservative lubricant.

Page 36, Par. 162 - APPLICATION TO DIESEL ENGINES

1. Retain paragraph with its reference to Naval Ship Technical Manual, Chapter 9412, "Diesel Engines." It is understood that revisions to Chapter 9412 are in preparation.

2. Additional comments on Chapter 9412 are shown in enclosure (2).

Page 41, Par. 183 - TANKS, FUEL OIL, DIESEL FUEL, GASOLINE, ALCOHOL, AND LUBRICATING OIL, AND THEIR CONTENTS.

1. Sub-paragraph 1.

   a. Revise to discontinue use of metal conditioning compound or thin film rust preventive compound, grade 2.

   b. Include a statement that all tanks should be protected by dehumidified air except as may be otherwise required for tanks of ships under MARAD custody which are berthed in locations where electrical power supply may be inadequate to provide necessary dehumidified air.

2. Sub-paragraph 3.

   Delete the words, "gas free" after the word, "qualified."

Page 95, Par. 187 - TURBINES, MAIN PROPULSION AND AUXILIARY STEAM, RECIPROCATING STEAM ENGINES, AND REDUCTION GEARS.

1. General.

   a. Replace grade 2 compound with VSI2190TEP lubricating oil for preserving interior surfaces of lubricating oil systems of turbines and reduction gears.

   b. It is understood that reciprocating steam engines now are preserved only with dehumidified air. Continue this practice.

2. Sub-paragraph 2.

   Delete paragraph.

3. Sub-paragraph 4.

   Delete first sentence.

Page 45, Par. 188 - DIESEL AND GASOLINE ENGINES.

Include a direct reference to Chapter 9412.

Page 46, Par. 189 - PROPELLERS AND MAIN PROPULSION SHAFTING.

Line 18:

Revise, "Non-corrosive propellers," to read, "Non-corrodible propellers."

Page 60, Par. 193 - DISTILLING PLANTS AND REFRIGERATING PLANTS.

Discontinue use of solvent cutback corrosion preventive because dehumidified air is an adequate corrosion preventive.

Page 60, Par. 194 - AIR COMPRESSORS.

1. Discontinue use of solvent cutback corrosion preventive.

2. Preserve with a product meeting MIL-L-21260. Note that precautions must be observed to ensure that all internal surfaces of components are wet initially by the preservative lubricant.

Page 60, Par. 195 - PURIFIERS.

1. For purifiers of lubricating oil systems other than for turbines:

   a. Discontinue use of solvent cutback corrosion preventive.

   b. Preserve with a product meeting MIL-L-21260. Note that precautions must be observed to ensure that all internal surfaces of components are wet initially by the preservative lubricant.

2. For purifiers of turbine oil lubricating systems:

   a. As for 1a above.

   b. Preserve with VS12190TEP.

   c. Include a note stating that products meeting MIL-L-21260 are likely to contain sulfonates and therefore must not be used in turbine oil lubricating systems.

Page 61, Par. 196 - HEATERS, OIL AND WATER.

Discontinue use of solvent cutback corrosion preventive because dehumidified air is an adequate corrosion preventive.

Page 61, Par. 197 - PUMPS.

Discontinue use of solvent cutback corrosion preventive and preserve with dehumidified air alone. If dehumidified air is a satisfactory preservative for pumps described in Par. 98 - STEAM PROPULSION PLANT, it should be equally effective for subject PUMPS.

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Page 66, Par. 200.2 - ELECTRONIC EQUIPMENT - RADIO, RADAR, INFRARED AND COUNTERMEASURES.

Revise second sentence:

"Replace corrodible hardware with non-corrodible material where practical."

Page 71, Par. 203 - HYDRAULIC SYSTEMS.

1. General:

   a. Retain sub-paragraph 4.

   b. Revise remaining sub-paragraphs.

   c. Replace the words, "hydraulic oil," with "hydraulic fluid," because the word, "oil," in this connection is a misnomer. Shipboard hydraulic fluids currently include four compositional classes of fluids as follows:

      (1) Waterbase fluids meeting Military Specifications MIL-H-5559A and MIL-H-22072.

      (2) Phosphate Ester fluids meeting Military Specification MIL-H-19457B.

      (3) Petroleum base fluids meeting Military Specifications MIL-H-5606, MIL-L-17331, and MIL-L-17672.

      (4) Silicone fluids meeting Military Specification MIL-S-81087.

      None of the above classes is compatible with the others. Their admixture must be avoided under all circumstances.

2. Discontinue use of solvent cutback corrosion preventive for inactivation.

3. For classes (1) and (2) above:

   a. Circulate the operational fluids through the systems until the discharge is free of particulate matter and any traces of water.

   b. Drain the fluids from the systems.

c. Replace with fresh charges of the appropriate operational fluids.

4. For systems requiring products meeting Military Specification MIL-L-17331:

   a. As for 3a and 3b above.

   b. Note that as soon as the specification for VSI2190TEP is issued, this product should replace MIL-L-17331 as a preservative fluid in surface ship systems where MIL-L-17331 is currently used.

5. For systems requiring products meeting Military Specification MIL-H-5606:

   a. As for 3a and 3b above.

   b. Preserve systems with products meeting Military Specification MIL-H-6083C. This product is fully operational for a limited time.

6. For systems requiring products meeting Military Specification MIL-L-17672:

   a. As for 3a, 3b, and 3c above.

   b. Note that as soon as products meeting Military Specification MIL-H-24430 are available, they should be used as the preservative fluid in the subject systems.

Page 72, Par. 206.7a - MINESWEEPING GEAR - ALL TYPES.

For gear to be stored in a dehumidified air zone:

Discontinue the use of solvent cutback corrosion preventive, because preservation by dehumidified air alone should be satisfactory.

Page 74, Par. 215 - GALLEY GEAR AND EQUIPMENT.

As for Par. 206.7a.

Page 86, Par. 252 - INSPECTION OF EXTERIOR SURFACES.

Discontinue the use of solvent cutback corrosion preventive for surfaces of equipment located within a dehumidified air zone.

Page 87, Par. 253 - DEHUMIDIFICATION.

Sentence No. 2: With regard to, "erratic or excessive operation

Encl (1), pg. 5, of NAVSHIPRANDCEN ANNALAB ltr 2841:HEA 4770 Work Unit No. 2841-512

of the dehumidification machines--,":

Add a note that malfunctioning of the relative humidity sensors also may be responsible for erratic or excessive operation, and that the sensors should be checked for operational integrity.

Page 93, Par. 321 - LUBRICATING SYSTEMS OF AUXILIARY TURBINES.

Preserve auxiliary turbine lubricating systems the same as for lubricating systems of main propulsion turbines. Refer to Par. 187.

Page 93, Par 322 - AUXILIARY STEAM SYSTEM (150 PSI).

Expand the current procedure which is restricted solely to removal of solvent cutback corrosion preventive, to include a parallel procedure applicable to systems preserved solely with dehumidified air.

Page 94, Par. 323 - AUXILIARY STEAM SYSTEM AND AUXILIARY EXHAUST SYSTEM (600 PSI).

As for Par. 322.

Page 94, Par. 324 - MAIN STEAM PIPING.

As for Par. 322.

Page 95, Par. 327 - CONDENSATE AND FEED SYSTEMS - MIXING OF CLEANING SOLUTION AND METHODS OF SAMPLING.

Retain paragraph as long as there are ships having above systems preserved with solvent cutback corrosion preventive.

Page 96, Par. 328 - CONDENSERS AND THE CONDENSATE AND AIR-EJECTING PIPING SYSTEM (NO. 1 ENGINE ROOM).

1. As for Par. 322.

2. Add procedures for cleaning and returning those systems which have been preserved solely by dehumidified air.

Page 97, Par. 329 - CONDENSERS AND THE CONDENSATE AND AIR-EJECTING PIPING SYSTEM (NO. 2 ENGINE ROOM).

As for Par. 328.

Page 97, Par. 330 - FLUSHING CONDENSERS, CONDENSATE AND AIR-EJECTING PIPING SYSTEMS (NO. 1 AND NO. 2 ENGINE ROOMS).

As for Par. 328.

Page 97, Par. 331 - DEAERATING FEED TANK AND THE FEED PIPING SYSTEM (NO. 1 FIRE AND ENGINE ROOMS).

As for Par. 328.

Page 98, Par. 332 - DEAERATING FEED TANK AND THE FEED PIPING SYSTEM (NO. 2 FIRE AND ENGINE ROOMS).

As for Par. 328.

Page 98, Par. 333 - FEED PIPING SYSTEM CROSSOVER LINES.

As for Par. 328.

Page 98, Par. 334 - FLUSHING THE DEAERATING FEED TANKS AND THE FEED PIPING SYSTEMS (NO. 1 AND NO. 2 FIRE AND ENGINE ROOMS).

As for Par. 328.

Page 98, Par. 335 - RECIPROCATING STEAM ENGINES.

As for Par. 322.

Page 99, Par. 337 - EVAPORATORS WITH STEEL SHELLS ONLY.

As for Par. 322.

Page 99, Par. 338 - TURBO-GENERATORS.

Revise as for Par. 321.2 to Par. 321.5.

Page 99, Par. 340 - DIESEL ENGINE LUBRICATING OIL SYSTEM.

1. Delete present paragraph.

2. Refer to reactivation procedures for these systems which are described in Naval Ships Technical Manual, Chapter 9412, "Diesel Engines."

Page 100, Par. 342 - BOILER SUPERHEATER AND ECONOMIZER.

As for Par. 322.

Page 100, Par. 343 - ATOMIZERS AND BRANCH TUBING.

As for Par. 322.

Encl (1), pg. 7, of NAVSHIPRANDCEN ANNALAB ltr 2841:HEA 4770 Work Unit No. 2841-512

Page 100, Par. 344 - LUBRICATION SYSTEMS OF MAIN PROPULSION SYSTEMS WITH REDUCTION GEARS.

Expand the current procedure which is restricted solely to systems preserved with solvent cutback corrosion preventive, to include also those preserved with VSI2190TEP.

Page 103, Par 345 - ACTIVATION OF GASOLINE SYSTEMS.

1. Sub-paragraph 345.1.C.

   After the words, "Remove seals and--," insert the words, "where applicable." This acknowledges the more recent practice of preserving the systems solely by dehumidified air.

2. Sub-paragraph 345.2 - Inert Gas Protective System.

   Reword first sentence as follows:

   "Where it has been applied, remove preservative from valves and lines in the inert gas system."

3. Sub-paragraph 345.3 - Gasoline Filling Stations.

   Reword first sentence as follows:

   "Where it has been applied, remove preservative from valves."

4. Sub-paragraph 345.4 - Degaussing Pumps.

   a. Discontinue application of preservative to equipment which is to be located in a dehumidified air zone.

   b. For pumps which have been preserved with solvent cutback corrosion preventive:

      Insert the words, "where applied," after the word, "preservative."

NAVAL SHIPS TECHNICAL MANUAL

CHAPTER 9412

DIESEL ENGINES

RECOMMENDED REVISIONS FOR BELOW DECKS UNITS

1. General Comment

Previous use of Military Specification MIL-C-16173, Compound, Corrosion Preventive, Solvent-Cutback, Cold Application," should be noted. Also, for diesel engines preserved with this material, current methods for returning the engines should be continued.

2. Paragraph 9412 115

Treatment for Preservation of Diesel Engines by Motoring.

Sub-paragraph 1(a): Revise to read, "MIL-L-21260, Type 1, Grade 30, for all fluid systems and internal surfaces of moderate and high speed diesel engines.

Sub-paragraph 2: Delete the parenthetical sentence, "Do not use grade 2 preservative in injection pumps or nozzles."

3. Paragraph 9412 116

Treatment for Laying Up Diesel Engines When Motoring Is Not Possible.

Revise the paragraph to replace all references to the use of solvent cutback corrosion preventive as a preservative with the use of MIL-L-21260, Type 1, Grade 30, for this purpose.

4. Paragraph 9412.117

Precautions

Revise the paragraph in its entirety to reflect the use only of MIL-L-21260, Type 1, Grade 30, as a preservative. Delete sub-paragraphs (4) and (5).

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5. Paragraph 9412.118

Starting Diesel Engines After Preservation With Compounds.

a. The current procedure for returning an engine which has been preserved with solvent cutback corrosion preventive should be continued. A second procedure applicable to engines preserved with MIL-L-21260 should be prepared.

b. Sub-paragraph 3: Concentration of the cleaning solution has been omitted.

Insert "2" before the word "percent" in the first sentence.

APPENDIX K

NSRDC/A LETTER "SHIP TOPSIDE ENCAPSULATION PROGRAM (AK 260); REVISION OF NAVAL SHIPS TECHNICAL MANUAL CHAPTER 9030, READINESS AND CARE OF VESSELS IN INACTIVE STATUS; TOPSIDES OF ENCAPSULATED SHIPS"

DEPARTMENT OF THE NAVY

NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

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IN REPLY REFER TO:

Annapolis Laboratory
2841:HEA
4770
Work Unit 2841-512
15 AUG 1972

From: Commander, Naval Ship Research and Development Center
To: Commander, Naval Ship Systems Command (NAVSHIPS 043)

Subj: Ship Topside Encapsulation Program (AR-260); Revision of Naval Ships Technical Manual, Chapter 9030, "Readiness and Care of Vessels in Inactive Status"; topsides of encapsulated ships

Ref: (a) NAVSHIPRANDCEN Center Annapolis Laboratory ltr. 2841:HEA 4770 Work Unit 2841-512, "Ship Topside Encapsulation Program (AR-260); Revision of Naval Ships Technical Manual, Chapter 9030, 'Readiness and Care of Vessels in Inactive Status,' below decks equipment," dated 9 Jun 1972
(b) Naval Ships Technical Manual, Chapter 9030, "Readiness and Care of Vessels in Inactive Status," dated Sep 1967
(c) Military Specification MIL-C-16173, "Solvent Cutback Corrosion Preventive"
(d) Naval Ship Research and Development Center Annapolis Laboratory Report S-837 of 13 May 1970, "Low Temperature Vapor Space Corrosion Inhibited Steam Turbine Oil; Evaluation of"
(e) Naval Ship Research and Development Center Annapolis Laboratory Report S-559 of 30 October 1970, "Low Temperature, Vapor Space Corrosion
(f) Military Specification MIL-L-21260, "Lubricating Oil, Internal Combustion Engine, Preservative"

Encl: (1) Recommended Revisions for Naval Ships Technical Manual, Chapter 9030, "Readiness and Care of Naval Ships in Inactive Status," topsides of ships preserved with air-supported structures.

1. Reference (a) includes recommendations for revisions of reference (b) with respect to below-decks equipment of ships preserved either by the conventional or topside encapsulation methods. Additional recommendations for revisions of reference (b) in order to incorporate more efficient practices for the topsides of ships preserved with air-supported covers, are the subject of this report.

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Work Unit 2841-512

2. The general intent of the revisions is to permit equipment positioned in the dehumidified air zone within the topside air-supported cover, to remain in an, "as-is", condition to the maximum extent possible, as explained in reference (a). Examples of topside equipment which no longer would have to be removed and stowed below decks in dehumidified spaces or elsewhere for a ship preserved with a topside cover, would include winch installations and auxiliary controls, guns and gun directors, other selected ordnance equipment, and many other topside equipment items identified in Paragraph 9030.284, "STOWAGE", of reference (b). Considerable time and labor such as identification of stowed gear, specifying topside location from which the gear was removed, and making required entries in the ships' Current Ships Maintenance Project (CSMP) file, activation list, and stowage plan would be eliminated. In addition to the foregoing, it no longer would be necessary to close many topside openings such as the stack, vents, ventilation ducts, etc., and to seal off topside electrical outlets positioned within the cover.

3. Advantages of eliminating the use of solvent cutback corrosion preventive, identified in reference (c), as a back-up preservative in dehumidified air zones and replacing it with proven preservative lubricating oils, also are detailed in reference (a).

4. It should be noted that in this report detailed recommendations have been made for modification of current preservation procedures applicable only to topside equipment under the cognizance of the Naval Ships Systems Command. It is recommended that current preservation procedures for topside equipment under the cognizance of other commands such as NAVAIR and NAVORD be reviewed by cognizant personnel to determine if comparable revisions can be made.

5. Recommendations and comments concerning revisions of reference (b) are given in enclosure (1). Individual items are identified by manual page and paragraph numbers, and by paragraph titles.

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RECOMMENDED REVISIONS FOR

NAVAL SHIPS TECHNICAL MANUAL, CHAPTER 9030

READINESS AND CARE OF NAVAL VESSELS IN INACTIVE STATUS

TOPSIDES OF SHIPS PRESERVED WITH AIR-SUPPORTED STRUCTURES

Page 4, Par. 24 - INACTIVATION (PHASE BRAVO)

1. Sub-paragraph 10a

   a. Revise the first sentence of the paragraph so that it begins with, "For ships preserved by other than topside air-supported structures of covers, as many topside equipments and fixtures as practical shall be removed and placed below decks under dehumidification; ---."

   b. Revise the current last sentence and then follow with two new sentences:

      "Electrical cables exposed to the weather shall be tagged, disconnected, and pulled into the ship. Electrical cables positioned in the dehumidified air zone within topside air-supported structures shall remain in place."

Page 5, Par. 24 - INACTIVATION (PHASE BRAVO) (CONT'D)

2. New sub-paragraph b

   "For ships preserved with a top-side air-supported cover, topside equipments and fixtures positioned in the dehumidified air zone within the cover remain in place to the maximum extent possible."

3. Current sub-paragraph 10b

   a. Reidentify as sub-paragraph 10c

   b. Revise as follows: "For ships preserved by other than topside air-supported covers, equipment which remains above deck shall be packaged (see article 9030.100) or preserved as part of the hull structure as applicable."

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c. Add two new sentences at end of paragraph:

"The preceding instruction does not apply to above deck equipment which will be located in the dehumidified air zone within the air-supported cover of a ship. In this case topside equipment remains in place to the maximum extent possible."

4. Current sub-paragraph 10c

a. Reidentify as sub-paragraph 10d

b. Add the following Note 1:

"This paragraph applies only to ships which have been preserved by means other than topside air-supported covers."

Page 6, Section II - PRESERVATION BY DEHUMIDIFICATION

As written, the current section applies only to ships preserved by the conventional procedure. Reorganization of the section to include ships preserved with a topside cover appears desirable. Accordingly, minor editorial revisions in addition to those specifically recommended below, may be required.

Page 6, Par. 72 - DEFINITIONS

1. Sub-paragraph 21. Zone

Add a new final sentence:

"For ships preserved with topside air-supported structures, the hull interior and the space within the topside structure constitute a single zone. The number and sizes of the dehumidifiers used will depend on the total volume of the single zone."

2. Add a new, Sub-paragraph 23 - Air Pressurization System

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2841-512

"The air-supported structure aboard the topside of a ship is inflated at an air pressure slightly above that of the outside air. Blowers draw outside air into a plenum where it is filtered and then discharged into the dehumidified air zone. Air pressure within the structure can be maintained at the required level either by automatic or manual controls mounted on a panel board. The air pressurization system may consist of a single stage or multiple stages. At relatively high wind velocities, the high pressure blowers are cut in automatically to raise the internal pressure for greater stiffening and hence to permit the structure to more readily withstand the increased wind inspect pressure."

Page 8, Par. 79 - DISTRIBUTION OF DRY AIR

Add the following note:

"Note 1. For ships preserved with air-supported structures: Topside packages are not needed for equipment positioned in the dehumidified air zone within an air-supported structure."

Page 10, Par. 93 - LOCATION OF DEHUMIDIFICATION MACHINES

Add a new second sub-paragraph:

"For ships preserved with topside air-supported structures all D/H machines shall be positioned at convenient locations on the main deck within the structure where they can be serviced readily."

Page 10, Par. 94 - CONTROL OF DEHUMIDIFICATION MACHINES

First Sub-paragraph

The current paragraph is concerned solely with preservation by the conventional method. An equivalent paragraph applicable to preservation by topside encapsulation should be added. Revision of the standard D/H diagrams applicable to ships preserved with topside air-supported structures should be checked by the cognizant NAVSEC code with NAVSHIPYD PHILA. Code 260.3 which designed the integrated single zone arrangement for USS BETELGEUSE (AK-260).

Encl(1), pg 3, of NAVSHIPRANDCEN ANNALAS 2: 2841:HEA 4770 Work Unit 2: 2841-512

Second Sub-paragraph

The present paragraph is concerned solely with preservation by the conventional method. A suggested paragraph applicable to ships with topside covers: "An elapsed-time indicator shall be installed on each D/H machine. The indicator and D/H machine control switches (in parallel with the humidistats) are to be located at a convenient position within and close to the entrance of the topside structure to facilitate operability checks".

Page 10, Par. 95 - CLOSING THE SHIP

1. Sub-paragraph 5

   a. Prefix the current paragraph with the phrase: "In the case of a ship preserved by the conventional method---"

   b. Add another paragraph: "For ships preserved with a topside air-supported structure, exhaust pipes ventilation openings, safety valve exhaust pipes, tank vents, drain pipes, voice tubes, etc. and the inner and outer stack openings which lead to and open into a topside structure need not be closed. This excludes vents and overflow lines for fuel, diesel, and JP-5 tanks which contain oil or are empty and have not been cleaned. In addition, all other openings leading from within the structure to the outside atmosphere must be closed.

2. Sub-paragraph 7

   Prefix the current paragraph with the phrase:

   "In the case of ships preserved by the conventional method---."

3. Insert a new sub-paragraph 8

   "For ships preserved with topside air-supported structure, spaces within the interior of the hull and the air-supported structure form one large integrated zone. In this case total air leakage is the sum of air losses from the hull interior, and from within the structure. The effectiveness of the topside structure for ship preservation is largely dependent on maintaining an air-tight seal between the sealing flap of

the structure and the ship. Rate of air leakage from the D/H zone must not exceed the rate at which dry make-up air can be supplied by the D/H machines. D/H machines are expected to operate at less than 50 percent of the time. If the D/H machines operate for more than 50 percent of the time, accuracy of the relative humidity sensors should be checked, a search for air leaks from within the cover should be made, and appropriate corrective action should be taken. For example, if under the foregoing condition, the D/H machines can supply a maximum volume of 400 cubic feet per minute of dry air, total air leakage ideally should not exceed this rate. However, in practice a safety factor of about 20 percent should be maintained so that in the example cited leakage rate should not exceed 320 cubic feet per minute.

"Air leakage tests aboard ships with top-side air-supported structures can be performed with a calibrated anemometer or inclined manometer by measuring air flow rate at one air intake to the air pressurization system. All other air intake openings should be closed while air leakage measurements are being made. The pressure of the air within the structure when the leakage tests are made, should be that which is maintained for wind velocities below 30 knots, and may be of the order of two inches water gauge pressure depending on the design and requirements of the individual structure. If the test shows excessive leakage, continue to search for and eliminate leaks until a satisfactory test is obtained.

4. Renumber current sub-paragraph 9, sub-paragraph 9

Page 11, Par. 95 - CLOSING THE SHIP (CONTD)

5. Add a new sub-paragraph 10

a. Additional procedures applicable to ships preserved with air-supported structures are required to repair leaks due to perforations of the cover itself or to separation of the cover from the ship to which it has been sealed with pressure sensitive tape. Such leaks must be

Encl(1), pg 5, of NAVSHIPRANDCEN ANNALAB lt 2841:HEA 4770 Work Unit N 2841-511

repaired promptly on discovery, not only to prevent loss of dehumidified air from within the cover, but also to prevent further damage to the cover assembly. Maintenance kits containing supplies of all materials required to make repairs to the cover are available at the local INACTSHIPFAC facility. In each case repairs must be made using materials equivalent to or better than those originally used by the contractor."

b. Perforations through the cover should be covered with patches observing all details of procedures described in the instruction manual provided by the contractor who has fabricated the cover. A copy of the instruction manual is on hand at the local INACTSHIPFAC facility."

c. Where the sealing flap of the structure has separated along its interface with the ship, fresh pressure sensitive tape sealant or adhesive should be applied along the length of the separation to the ship's half of the interface. The sealing flap of the structure is fitted over the adhesive and pressure is applied to assure firm adhesion of the sealing flap to the ship. One form of pressure sensitive tape is paper-backed in a roll, and is applied readily. Usually one line of adhesive, along the sealing flap interface with the ship, is adequate. In any case pressure sensitive tape equivalent to that originally applied during installation of the structure must be used.

Page 15, Par. 100 - PACKAGING

Sub-paragraph 1, General.

1. Revise the first sentence to read as follows:

"Equipment which is subject to deteriorat[illegible] which is installed on the weather decks (o[illegible] located outside a topside air-supported structure) and cannot be effectively preserved by use of paint and/or other protective coatings, is to be protected aboard ship within a metal pacakage or stored aboard ship in a D/H zone, or removed from the ship (see article 9030.24.10).

Encl(1), pg, 6
NAVSHIPRANDCEN ANNALAB ltr.
2841:HHA 4770 Week [illegible]

Page [illegible] 100 - PACKAGING (CONT'D)

2. Sub-paragraph 1, line 2:

Insert after the word, "decks," the phrase, "or outside a topside air-supported structure."

Page 18 SECTION II

A new Part IV should be inserted after paragraph 113 of Part III as follows:

Part IV AIR PRESSURIZATION SYSTEMS INSPECTION AND MAINTENANCE STANDARDS

Part IV applies only to ships preserved with a topside air-supported structure (appropriate numbers should be assigned to the individual paragraphs identified below.)

Par. - INSPECTIONS

1. Inspection Schedule. After inactivation (or after any prolonged period where the air blowers have been inoperative) inspections of all components of the system are to be made on the following schedule (see Note 1):

a. Immediately after the D/H and air pressurization systems have been energized and checked for proper performance

b. At the end of the first week

c. At the end of the third week

d. At the end of the fifth week (see Note 2)

e. At the end of the twelfth week

f. Every three months thereafter.

Note 1. These inspection frequencies are authorized only after security, watertight integrity, and weathertight integrity (including air testing and sealing) requirements of the ships have been met. Ships which have not completed ship tightness requirements, are to be inspected at least once a month.

Encl(1), pg 7, of NAVSHIPRANDCEN ANNALAB ltr 2841:HEA 4770 Work Unit No 2841-512

Note 2. If the air pressurization system is functioning properly at this time, inspections may be put on a quarterly basis. If malfunctioning of the system is observed, corrective action should be taken and inspections conducted every two weeks until desired conditions are achieved, at which time inspections can revert to the quarterly basis.

2. During the routine inspections, the following shall be performed:

   a. Operation of the complete air pressurization system shall be noted. Air pressure within the cover shall be checked for indication of non-compliance with requirements.

   b. Routine preventive maintenance for the instrumentation and machinery components of the air pressurization systems shall be accomplished as required.

Par. - AIR PRESSURIZATION SYSTEM OPERABILITY CHECK

1. Equipment operability checks are to be conducted on a monthly basis except that they should be combined with the routine inspections when the times for these two inspections coincide. These checks can be conducted simultaneously with those for D/H machine operability (see article 9030.112).

2. Specific operability checks to be conducted are:

   a. Panel Board.

      Instrumentation and controls shall be checked for ready response to changes in wind velocity and to effect appropriate changes in the pressure of the air within the cover. Some panel boards may be equipped to permit simulation of these changes by manual operation of controls. Other boards may require different manipulation to simulate these changes.

Encl(1), pg 8, of NAVSHIPRANDCEN ANNALAB lt 2841:HEA 4770 Work Unit No 2841-512

Air Intake Ducting

The ducting shall be checked for evidence of abrasion, perforation, and integrity of connections.

c. Blower Motors and Fans

Response of the low and high pressure blower motors and fans to manual operation of panel board controls shall be checked.

d. Fan Drives

Belt drives shall be checked for evidence of excessive belt wear, and for improper tension and fit of belts. Direct and gear drive mechanisms shall be checked for excessive vibration and noise, misalignment, coupling adjustment, and for other evidence of malfunctioning.

e. Air Discharge Shutters

The shutters shall be checked for free movement in response to changes in pressure of incoming air.

f. Air Filters

Filters shall be checked for evidence of clogging and damage.

Par. - AIR PRESSURIZATION SYSTEM - MAINTENANCE STANDARDS

1. Maintenance work on components of air pressurization system shall be required as a result of faulty performance which may be attributable to any of the following:

a. Malfunctioning of instrumentation and controls mounted on the panel board.

b. Damage to or poor connections associated with the intake air ducting.

c. Malfunctioning of air blower motors.

Encl(1), pg 9, of
NAVSHIPRANDCEN ANNALAB ltr
2841:HEA 4770 Work Unit No
2841-512

d. Malfunctioning of air blower fans.

e. Excessive wear or poor tensioning of fan belts

f. Faulty operation of the air discharge shutters

g. Clogging of air filters

2. Corrective work should be accomplished as soon as the need for same is determined. The successful preservation of ships by means of the air-supported cover concept requires a capability to provide a continuous supply of pressurized air adequate to support the cover at the required pressure.

a. Panel Board

Instrumentation and controls should provide ready response to changes in wind velocity which require rapid changes in the pressure of the air within the cover. These changes can be simulated by manual operation of controls. The contractor who has fabricated the cover shall supply instruction manuals which include all details of the instrumentation and controls on the panel board. The local INACTSHIPFAC facility will have on hand copies of the manuals.

b. Air Intake Ducting

Repairs should be made as required

c. Blower Motors

Maintenance should be conducted as directed in the instruction manual

d. Blower Fans

Maintenance should be conducted as directed in the instruction manual

Encl(1), pg 10, of
NAVSHIPRANDCEN ANNALAB ltr
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2841-512

e. Fan Belts

Fan belts should be replaced if evidence of excessive wear is noted. Belt tension should be adjusted as required.

f. Air Discharge Shutters

Free movement of the shutters in order to respond to changes in blower air pressure, must be assured. Lubricant should be applied as required.

g. Air Filters

The filters should be cleaned periodically as required.

3. Specific procedures are to be placed in effect to reduce access to the ship to the barest minimum consistent with adequate security and maintenance, except those in a disposal, activation, or special category.

Page 18

A new Part V should be inserted after the last paragraph of new Part IV as follows:

Part V TOPSIDE AIR-SUPPORTED STRUCTURE INSPECTION AND MAINTENANCE STANDARDS

Part V applies only to ships preserved with topside air-supported structures. (Appropriate numbers should be assigned to the individual paragraphs identified below)

Par. - INSPECTIONS

1. Inspection Schedule

After inactivation (or after any period when the air pressurization system has been inoperative) inspections of all portions of the structure assembly

Encl(1), pg 11, of NAVSHIPRANDCEN ANNALAB lt 2841:HEA 4770 Work Unit N 2841-512

are to be made on the following schedule (see Note 1):

a. Immediately after the D/H and air pressurization systems have been energized and checked for proper performance

b. At the end of the first week

c. At the end of the third week

d. At the end of the fifth week (see Note 2)

e. At the end of the twelfth week

f. Quarterly thereafter

Note 1. These cover inspection frequencies are authorized only after security, watertight integrity, and weathertight integrity (including air pressurization and sealing) requirements for the ships have been met.

Note 2. If the air-supported structure system is functioning properly at this time, inspections may be put on a quarterly basis. If malfunctioning of the system is observed, corrective action should be taken and inspections conducted every two weeks until desired conditions are obtained, at which time inspections can revert to the quarterly basis.

2. During the routine inspections of the cover system, the following shall be performed:

a. Where applicable, the transverse reinforcing cables should be checked to make certain that they remain fastened securely to the pad-eyes welded to the ship's hull end for evidence of rusting or other degradation.

b. Where applicable, the catenary cable system along the edge of the cover and extending around the ship should be checked to make certain that the nuts fastening the cable clips to the studs on the ship's hull are tight, and to detect other evidence of malfunctioning.

Encl(1), pg 12, of NAVSHIPRANDCEN, ANNALAB 1 2841:NER 4770 Work Unit N 2841-512

c. The exterior of the structure should be checked for evidence of abrasion or wearing away of the protective paint, for evidence of punctures or rips in the cover material, or of rupture or parting of the bonding between adjacent panels, or for other signs of malfunctioning.

d. Boot and shroud assemblies fastened around masts, king posts, or other topside units which project through the structure, should be checked for evidences of wear, punctures or rips, failure of bonding, or other signs of malfunctioning.

e. The interior of the structure should be checked for evidence of pinholes or other perforations (see Note 1), or of contact with topside projections (see Note 2).

Note 1. Pinholes or perforations in the structure can be detected most readily from within the cover by the daylight shining through them.

Note 2. Contact between the cover and topside projections within the cover is not anticipated. However, this check should be made in the event the air pressure within the structure has fallen below minimum requirements, or because of unusually high velocity wind gusts.

f. The integrity of the seal between the sealing flap of the cover and the ship proper should be checked. The two surfaces are joined by means of a strip of an adhesive mastic.

g. Operation of the airlock closure mechanisms and, where fitted, of the pressure relief valves of the entrance and exit closures of the entrance and exit closures of the cover, should be checked. Leakage of air through these components and along the interface between the enclosures and the ship proper should be checked.

Par. - AIR-SUPPORTED STRUCTURE OPERABILITY CHECK.

1. Operability checks should be conducted at the same time that operability checks of the air pressurization system are made (see article 9030.).

Par. - MAINTENANCE STANDARDS

1. Topside cover system maintenance work shall be required as follows:

   a. Where the previous coat of protective paint has worn away, apply a fresh coat of the paint previously used. The local INACTSHIPFAC facility will have on hand a supply of the paint.

   b. Perforation or rips on the cover boots, or shrouds should be repaired promtly, following all details of the procedure described in the instruction manual provided by the contractor who fabricated the cover. The local INACTSHIPFAC facility will have on hand a copy of the manual.

   c. Where the sealing flap of the cover has pulled away from the ship proper, remove the exposed remnants of pressure sensitive tape adhesive from the flap and ship, and press the two surfaces together firmly. The tape adhesive is non-volatile and non-hardening, and meets requirements of Military Specification MIL-C-18969B, Type 2, Class B, "Calking Compounds, Metal Seam and Wood Seam" (see Note 1). The tape is available in a paper-backed roll form and is readily applied. The local INACTSHIPFAC facility will have on hand a supply of the tape.

   d. Necessary repairs shall be made to entrance and exit enclosures of the cover in order to assure satisfactory operation of the air-lock closure mechanisms and the pressure relief valves. Openings causing the leakage of air through these components and along the interface between the enclosures and the ship proper should be sealed.

Encl(1), pg 14, of NAVSHIPRANDCEN, ANNALAB, letter 2841:HEA 4770 Work Unit No. 2841-512

Note 1. Although the pressure sensitive tape adhesive is classified generally as non-hardening, it is apt to harden over an extended period, perhaps five years. For this reason, strength of the seal between the sealing flap of the air-supported structure and the ship proper should be checked at random locations at yearly intervals after the second year subsequent to installation of the structure. If there is evidence that the sealant has hardened so as to impair the effectiveness of the seal, another application of the pressure sensitive tape within the line of the previous application, should be made.

2. Corrective work to repair the cover of the structure should be conducted as soon as the need for same is determined. The successful preservation of ships by means of topside air-supported structures depends largely upon maintaining the cover free from defects which permit the relative humidity of the internal air to rise above the maximum permissible limit.

3. Specific procedures are to be placed in effect to reduce entering the ships to the barest minimum consistent with adequate security and maintenance, except those in a disposal, activation or special category.

Page 1, Par. 155 - REMOVAL (OF SOLVENT CUTBACK CORROSION PREVENTIVE)

Retain paragraph in order to provide instruction for handling ships which have been preserved with solvent cutback corrosion preventive.

Page 4, Par. 158 - FLUSHING PROPERTIES (OF SOLVENT CUTBACK CORROSION PREVENTIVE)

The current paragraph is applicable only to ships preserved by the conventional method and should be retained to provide instruction for ships which are to be preserved by the conventional method. A note should be added stating that for ships preserved with air-supported structures, this paragraph applies only to equipment exposed to the weather.

Par. 160 - APPLICABLE GRADE

Sub-paragraph 1

a. Add new first sentence:

"Use of solvent cutback corrosion preventive should be discontinued for the following situations:

(1) For ships preserved by the conventional method: for interior corrodible surfaces exposed to dehumidified air.

(2) For ships preserved by topside air-supported structures: for all corrodible surfaces exposed to dehumidified air either within the hull or within the topside cover."

b. Delete sentence:

"Grade 2 only shall be used for flushing through lubrication systems"

2. Sub-paragraph 2

Delete words:

"---interior and ---", from current first sentence.

Page 36, Par. 161 - APPLICATION TO PIPING AND GEARS

Use of solvent cutback corrosion preventive should be discontinued for the equipment which is located in dehumidified air zones. It should be replaced by Vapor Space Inhibited Steam Turbine Oil (VSI2190TEP), references (d) and (e), or by MIL-L-21260, reference (f) dependent on operational components used in individual units. Precautions must be observed to ensure that all internal surfaces of components are wet initially by the preservative lubricant, as indicated on page 1 of enclosure(1) of reference (a).

Page 37 Par. 175 - SIDES ABOVE WATER, DECKS, AND UPPER WORKS, STEEL

1. Sub-paragraph 2c

Add a sentence:

"Application of bituminous emulsion is not required for deck areas positioned in the dehumidified air zone within a topside air-supported cover.

2. Sub-paragraph 2e

Replace the word, "with", by the word, "within", in the fifth line.

3. Sub-paragraph 3. Structural Expansion Joints.

It is recommended that the cognizant NAVSEC code familiar with the details of structural expansion joint construction aboard the individual classes of ships review the paragraph to determine the need for revisions applicable to ships preserved with topside air-supported structures. Seemingly, those expansion joints positioned in a dehumidified air zone within a topside air-supported structure could be left in an "as is" condition subject to such maintenance as would be required to continue them in operating condition.

Page 38, Par. 178 - MASTS, SPARS, BOOMS, CRANES, BOAT DAVITS, RIGGING, LIFE LINES, AND STANCHIONS

1. Paragraph 2. Wire Rope

a. Sub-paragraph 2a

In the first sentence after the word, "location", insert the words, "---including within a topside air-supported structure, ---."

b. Sub-paragraph 2c

Insert a new sub-paragraph 2c:

Encl(1), pg 17, of NAVSHIPRANDCEN, ANNALAB ltr 2841:HEA 4770 Work Unit No. 2841-512

"All rigging which has been in use and exposed to the weather but is positioned in the dehumidified air zone within a topside air-supported cover, should be left in place and given maintenance needed to continue it in operating condition.

c. Current sub-paragraph 2c

Reidentify as sub-paragraph 2d

d. Current sub-paragraph 2d

(1) Reidentify as sub-paragraph 2e

(2) Add the following sentences at the end of the sub-paragraph:

"Sheaves and pins from davits and cranes which are positioned in the dehumidified air zone within a topside air-supported structure, need not be removed for stowage below decks but should be given maintenance as needed to continue them in an operating condition."

Page 40, Par. 178 - MASTS, SPARS, BOOMS, CRANES, BOAT DAVITS, RIGGIN, LIFE LINES, AND STANCHIONS (CONT'D)

Sub-paragraph 3

Insert a new second sentence:

"Portable lifeline stanchions and lifelines positioned in the dehumidified air zone within a topside air-supported structure, should remain in place and be given maintenance as needed to continue them in an operating condition."

Page 40, Par. 179 - CORDAGE

Sub-paragraph 1

Reword to read as follows:

"The ship's full allowance of manila, hemp, sisal and other rope and small stuff, except mooring lines necessary to secure the ship in its berthing area, shall be stowed in a dehumidified space, either below decks or in the dehumidified air zone within a topside air-supported structure."

Encl(1), pg 18, of NAVSHIPRANDCEN, ANNALAB, ltr 2841:HEA 4770 Work Unit No. 2841-512

Page 40, Par. 180 - ANCHORS, CHAINS, AND CHAIN LOCKERS

Sub-paragraph 3

Delete the last sentence and replace with:

"Chain lockers of surface ships preserved by either the conventional or topside air-supported structure methods shall be sealed and preserved by dynamic, forced draft dehumidification."

Page 40, Par. 181 - SHIPS', BOATS, LIFE FLOATS, AND FLOATER NETS

1. Sub-paragraph 2

   a. Insert at the beginning of the paragraph. the phrase:

      "For ships preserved by the conventional method ---."

   b. Insert the following before the current last sentence:

      "For ships preserved with topside air-supported structures, metal lifeboats may be stowed on deck in an upright position. Engines, if installed, shall remain in place."

2. Sub-paragraph 3

   Add a new last sentence:

   "For ships preserved with topside air-supported structures, life floats can be stowed on deck within the structure."

3. Sub-paragraph 4

   Rewrite as follows:

   "Floater nets shall be stowed in a dehumidified space, either below decks or within a topside air-supported structure. They should be hung up if space is available."

Encl(1), pg 19, of NAVSHIPRANDCEN, ANNALAB, lt 2841:HEA 4770 Work Unit No 2841-512

Sub-para

Understanding of the current sub-paragraph could be improved by changing either the word "stowage" to "stowages" or the word "are" to "is".

Page 55, Par. 192 - ANCHOR ENGINES, STEERING ENGINES, CAPSTANS, ELEVATOR MACHINERY, HOISTS, CABLE REEL MACHINERY, GATE RAMP MACHINERY, CRANE MACHINERY, DAVIT WINCHES, DECK WINCHES, AND RUDDERS.

1. Sub-paragraph 3 - Winches, electrically driven.

It should be noted that current instructions apply to ships preserved by the conventional method. For ships preserved with topside air-supported structures, the following instructions should apply:

"All winches positioned in the dehumidified air zone of a topside air-supported structure shall be continued in first class operating condition and shall remain in place. Gear boxes shall be preserved with Vapor Space Inhibited Steam Turbine Oil (VSI2190TEP) references (d) and (e), eliminating use of solvent cutback corrosion preventive. In all cases precautions must be observed that all internal surfaces are wet initially by the preservative lubricant."

2. Sub-paragraph 5

Reword as follows:

"All other machinery within the machinery platform on pedestal type cranes above the weather decks of ships preserved by the conventional method or outside the cover of ships preserved with topside air-supported structures, must be preserved as though exposed to the weather, using the accepted preservation procedure for the item involved."

Encl(1), pg 20, of NAVSHIPRANDCEN, ANNALAB, ltr 2841:HEA 4770 Work Unit No. 2841-512

Page 61, Par. 198 - ELECTRICAL EQUIPMENT

1. Sub-paragraph 1h

   a. Prefix the current third sentence with:

      "For ships preserved by the conventional method---."

   b. Insert a new fourth sentence:

      "For ships preserved with topside air-supported structures, new replacement equipment shall be installed."

2. Sub-paragraph 3a, Details of preservation

   Insert new second and third sentences:

   "Use of solvent cutback corrosion preventive should be discontinued wherever possible. Its use in dehumidified air spaces should be eliminated." Then follow with current sentences.

3. Sub-paragraph 6b

   a. Revise the first sentence to read:

      "Topside motors located outside an air-supported structure or otherwise exposed to weather conditions shall be removed and stored below in dehumidified spaces"

   b. Add new final sentence:

      "Topside motors located in a dehumidification zone within a topside air-supported structure, shall remain in place."

4. Sub-paragraph 6e

   Rewrite as follows:

   "For ring-lubricated sleeve bearings, drain the oil from bearings and reservoirs. Flush the bearings and reservoir with VSI290TEP identified in reference (d) and (e), taking care to ensure that the preservative lubricating oil comes into contact

paragraph 6e

with all corrodible surfaces of the shaft and bearings. The preservative lubricating oil shall be introduced carefully (avoid splashing on the insulation of the machine) into the inspection hole in the top of the bearing until the oil in the lubrication system attains its normal level."

5. Sub-paragraph 6f

Rewrite as follows:

"For forced feed bearings, drain the lubricating oil system, and replace with VSI2190TEP in accordance with article 9030.161"

6. Sub-paragraph 6h

Rewrite as follows:

"Apply VSI2190TEP to shafts and couplings making certain that all internal surfaces are wet initially with the preservative lubricating oil. However, no preservative lubricating oil shall be used inside the motor housing, except as required by paragraph (j) below."

7. Sub-paragraph 6j

Revise first sentence as follows:

Replace the current words, "---solvent cutback corrosion preventive---," with "--- VSI2190TEP ---"

8. Sub-paragraph 7, Controllers

Rewrite second sentence as follows:

"Where installed in a dehumidified space, no additional preservation measures are required."

9. Sub-paragraph 9, Searchlight

Add a note stating that, "Searchlights positioned within a topside air-supported structure shall remain in place"

Encl(1), pg 22, of NAVSHIPRANDCEN, ANNALAB, 1 2841:HEA 4770 Work Unit No 2841-512

10. Sub-paragraph 12, Repair parts for electrical equipment

Replace the words, "--- rust preventive compound ---," with, "--- VSI2190TEP ---", throughout the paragraph.

11. Sub-paragraph 13b. Lighting Fixtures

Add a sentence:

"Portable light fixtures located within a topside air-supported structure shall remain in place"

Page 64, Par. 199 - INTERIOR COMMUNICATION, FIRE CONTROL, AND GYRO COMPASS EQUIPMENT

1. Sub-paragraph 5

a. Prefix the first sentence with the phrase:

"For ships preserved by the conventional method ----

b. Insert a new third sentence:

"Superpower reproducers positioned within the cover of a topside air-supported structure shall remain in place."

2. Sub-paragraph 6b. Switches, telephone jackboxes, and other fittings

Add a new final sentence:

"Above items when located in a dehumidified air zone within a topside air-supported structure, remain in place and require no supplementary installation of ducting."

3. Sub-paragraph 7. Gyrocompass equipment, dead reckoning equipment, self-synchronous alidade equipment, and pelorus stands.

a. Item a (5)

Replace the words, "--- solvent cutback corrosion preventive, grade II, ---" with "VSI2190TEP"

b. Item b (4)

As for Item a (5) above

c. Item d

As for Item a (5) above

Page 73, Par. 219 - MAGNETIC COMPASS AND PELORUS EQUIPMENT

1. Sub-paragraph 1

Delete the second sentence. It is recommended that the use of solvent cutback corrosion preventive be discontinued for equipment stored in a dehumidified air zone.

2. Sub-paragraph 2

Delete the last sentence for the same reason described in sub-paragraph 1 above

3. Sub-paragraph 3

As for sub-paragraph 2 above

Page 76, Par. 224 - WHISTLES AND SIRENS

1. Current paragraph - unnumbered

a. Renumber paragraph 1

b. Prefix paragraph with the phrase:

"For ships preserved by the conventional method ---."

2. Add a new paragraph 2 as follows:

"For ships preserved with topside air-supported covers, damaged insulation should be replaced with new covering. Perform maintenance as required, to continue the equipment in operating condition.

Encl(1), pg 24, of NAVSHIPRANDCEN, ANNALAB, ltr 2841:HEA 4770 Work Unit No. 2841-512

1. Sub-paragraph 1

   Add a new final sentence:

   "All external portions of the ventilation system positioned in the dehumidified air zone within a topside air-supported structure shall remain in place."

2. Sub-paragraph 2

   a. Insert a new third sentence:

      "Ventilation ducts positioned in the dehumidified air zone within a topside air-supported structure need not be blanked (except as required to control flow of D/H air within the zone)."

   b. Add a new final sentence:

      "After repairs or replacement, ventilation screens positioned in the dehumidified air zone within a topside air-supported structure may be installed."

Page 89-90, Par. 284 - STOWAGE

1. The subject paragraph identifies 54 typical examples of topside gear which, "--- are permitted to be stowed below deck in a dehumidified space." Significant savings in time and labor can be realized through elimination of this stowage for ships preserved with a topside air-supported structure.

2. Insert the following phrase at the beginning of the last sentence of the first paragraph:

   "For ships preserved by the conventional method ---."

Encl(1), pg 25, of NAVSHIPRANDCEN, ANNALAB, ltr. 2841:HEA 4770 Work Unit No. 2841-512

3. Add a new final paragraph as follows:

"For ships preserved with an air-supported structure: apart from easily pilferable articles which must be secured as described in the preceding paragraph, all other topside gear included among the foregoing examples which is located in the dehumidified air zone within the structure, remains in place."

4. It should be noted that the above revision is not intended to include topside gear under the cognizance of NAVORD or NAVAER, which should be handled separately as recommended in the body of this report.

Page 90, Par. 302 - PREPARATORY STEPS

Sub-paragraph 1a

Add a sentence:

"This includes removal of the topside air-supported structure from ships preserved by this method."

Encl(1), pg 26, of
NAVSHIPRANDCEN, ANNALAB ltr.
2841:HEA 4770 Work Unit No.
2841-512

APPENDIX L

NSRDC/A LETTER "SHIP TOPSIDE ENCAPSULATION PROGRAM (AK 260); COST-TIME BENEFIT ANALYSIS

DEPARTMENT OF THE NAVY
NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER
HEADQUARTERS
BETHESDA, MARYLAND 20034

284

ANNAPOLIS LABORATORY
ANNAPOLIS, MD 21402
CARDEROCK LABORATORY
BETHESDA, MD 20034

IN REPLY REFER TO:
Annapolis Laboratory
2841:HEA
4770
Work Unit 2841-512

25 JUL 1972

From: Commander, Naval Ship Research and Development Center
To: Commander, Naval Ship Systems Command (NAVSHIPS 043)

Subj: Ship Topside Encapsulation Program (AK-260); cost-time benefit analysis

Ref: (a) NAVSHIPRANDCEN Annapolis Laboratory, ltr 2841:HEA 4770 Work Unit 2841-512, "Ship Topside Encapsulation Program, Meetings with NAVMAT 03L," of 19 Apr 1972
(b) NAVSHIPRANDCEN Annapolis Laboratory, ltr 2841:HEA 4770 Work Unit 2841-512, "Ship Topside Encapsulation, Performance of Cover Aboard USS BETELGEUSE (AK-260)," of 4 Feb 1972
(c) Naval Ship Technical Manual, Chapter 9030, "Readiness and Care of Naval Vessels in Inactive Status," of Sep 1967
(d) INACTIVE SHIP MAINTENANCE FACILITY NORFOLK, CHARLESTON DETAIL (INACTSHIPFAC NORVA CHASN DET) Ship Inactivation Progress Report Final Report, USS BETELGEUSE AK(FBM)260 of 14 Jan 1971
(e) NAVSHIPRANDCEN Annapolis Laboratory, ltr 2841:HEA 4770 Work Unit 2841-512, "Ship Topside Encapsulation Program (AK-260); Revision of Naval Ships Technical Manual, Chapter 9030, 'Readiness and Care of Naval Vessels in Inactive Status, below decks equipment'," of 9 Jun 1972
(f) PHILADELPHIA NAVAL SHIPYARD (NAVSHIPYD PHILA) ltr, Code 239 (AJB) AK-260, "USS BETELGEUSE (AK-260); Mechanized Departure Report for," of 27 Jan 1972
(g) NAVSHIPYD PHILA Code 249 Value Engineering, Memo, "Topside Cover for AK-260, Value Engineering Review," of 27 Jan 1972
(h) BIRDAIR STRUCTURES INC., ltr, Ref: 70-74, "Estimated prices for follow-on ship covers," of 24 Jan 1972
(i) NAVSHIPRANDCEN Rept S-650, "Novel Long-Term Preservation System for Ships' Topsides and Superstructures," of Mar 1971

Encl: (1) Ship Inactivation, Cost-Time Benefit Analysis and Details of Estimates, (5 sheets)
(2) Inactive Ship Maintenance, Cost-Time Benefit Analysis and Details of Estimates, (3 sheets)
(3) Ship Activation, Cost-Time Benefit Analysis and Details of Estimates, (2 sheets)
(4) Ship Activation, Four AKA Class Ships, Estimated and Final Costs (1 sheet)
(5) Comparative Inactivation and Activation Cost-Time Estimates for Ships Having Generally Similar Hull Dimensions (1 sheet)

Annapolis Laboratory
2841:HEA
4770
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1. Practicability of single wall air-supported structures to serve as shelters in a variety of applications is well established. Performance records indicate that service lives significantly longer than 10 years under a broad spectrum of climatic condition can be expected for structures made of selected material combinations, as shown in enclosure (4) of reference (a).

2. Performance of the prototype single wall air-supported structure aboard the topside of AK-260 has been satisfactory during the short period of service since its installation in October 1971. Subsequent to the "drying out" period, relative humidity of the air within the cover has been maintained readily at the desired level, i.e., about 35 percent. A few small holes in the cover have been detected and repaired. Personnel of INACTIVE SHIP MAINTENANCE FACILITY PHILADELPHIA (INACTSHIPFAC PHILA) have provided more effective seals at several locations between the flanges at the bases of the walls of the mooring station enclosures and the deck of the ship. These modifications have enhanced structural air-tightness. The cover has weathered wind velocities up to 46 knots, the highest velocities experienced since installation eight months ago, as described in reference (b). The cover appears to be continuing its function of maintaining the topside areas in a well-protected condition. Based on available data, an indicated service life well in excess of 10 years appears attainable for the air-supported structure aboard AK-260, attesting to the technical feasibility of the topside encapsulation concept.

3. A cost-time effectiveness analysis of the concept as applied to AK-260 or to a similar fleet auxiliary is the subject of this report. Cost-time estimates for the long term preservation of the ship over the inactivation/activation cycle by the topside encapsulation and standard methods have been developed. Summarized results are compared in the table on page 3.

4. Development of topside encapsulation from the prototype installation to its fullest proposed implementation has been divided into three phases for purposes of analysis. The current program with AK-260 is Phase I and includes all developmental and redundant costs. For Phase II developmental and redundant costs are deducted. In these first two phases ship's force and industrial force work has been performed in most respects according to procedures described in reference (c). However, estimates for Phase III are based on an encapsulation procedure projected to its maximum development. This maximum development would consist of extensive revision of reference (c) and on significant simplification of both cover design and ship topside preparations required to accommodate the cover.

5. The estimates for Phase III and the standard method indicate the labor

COST-TIME BENEFIT ANALYSIS-ESTIMATES
SUMMARY
INACTIVATION/MAINTENANCE/ACTIVATION; AK-260

	NAVAL SHIP TECHNICAL MANUAL				
	PRESENT CHAPTER 9030 APPLIES			REVISED CHAPTER 9030 APPLIES	ESTIMATED
		TOPSIDE ENCAPSULATION			SAVINGS:
	STANDARD METHOD OF PRESERVATION	PHASE I CURRENT AK-260 PROGRAM; ALL COSTS INCLUDED	PHASE II DEVELOPMENT AND REDUNDANT COSTS BACKED OUT	PHASE III ENCAPSULATION CONCEPT IMPLEMENTED TO FULLEST EXTENT	STANDARD LESS PHASE III
CTIVATION					
MAN-DAYS	10,780	14,549	11,490	10,153	627
COSTS, $K (1)(3)	1,111	1,902	1,385	1,263	(152)
TIME TO COMPLETE, MONTHS	5	7	5	3-1/2	1-1/2
NTENANCE, 15 YEARS					
MAN-DAYS	2,900	3,450	3,450	3,450	(550)
COSTS, $K (2)(3)	185	246	245	246	(61)
IVATION					
MAN-DAYS	11,996	11,663	11,248	10,105	1,891
COSTS, $K (1)(3)	1,536	1,503	1,459	1,345	191
TIME TO COMPLETE, MONTHS	3	3	3	2	1
CTIVATION/ACTIVATION CYCLE					
MAN-DAYS	25,676	29,662	26,183	23,708	1,968
COSTS, $K (3)	2,832	3,651	3,090	2,854	(22)
TIME TO COMPLETE, MONTHS (EX MAINTENANCE)	8	10	8	5-1/2	2-1/2

TES: (1) COSTS INCLUDE LABOR CALCULATED AT $100/MAN-DAY, CURRENT NAVSHIPYD PHILA INDUSTRIAL FORCE RATE PLUS MATERIALS.
(2) COSTS INCLUDE LABOR CALCULATED AT $23.50/CIVILIAN MAN-DAY, INACTSHIPFAC PHILA RATE AND MATERIALS.
(3) CONSTANT DOLLARS USED THROUGHOUT.

savings of approximately 9 man-years may be realized over the total inactivation-activation cycle. For the activation segment alone, potential labor savings of nearly 8.5 man-years appear possible. It also is estimated that the total time required to complete activation of an encapsulated ship would be only two months instead of the three months presently required for a ship preserved by the standard procedures. These magnitudes of labor and time savings for activation could provide a marked advantage during a national emergency.

6. Estimated overall costs for the inactivation/activation cycle by both Phase III encapsulation and the standard methods are about the same. This is attributable principally to the unavoidable initial cost of the cover. It has been assumed in this analysis that the cover would have depreciated to zero value when removed. This would not be the case for dimensionally identical ships of the same class where a cover could be removed from one ship and installed aboard a sister ship. This would be a common occurrence if rotation of identical ships in and out of active status was considered to be advantageous.

7. Background information and details of estimates of cost and time for the inactivation, maintenance, and reactivation of AK-260, preserved by either standard or encapsulation methods, are included in enclosures (1), (2), and (3) respectively.

8. Comparative inactivation/activation cost-time estimates for a group of ships having hull dimensions generally similar to those of AK-260, are shown in enclosure (4). Inactivation and activation data have been estimated for AK-260 preserved by topside encapsulation, Phases II and III. For all others, sources of inactivation and activation data include final ships' progress reports, ship departure reports, and activation work packages.

9. The wide ranges bracketing inactivation returned costs and time, and activation work package estimates, attest to the inadvisability of attempting to develop average base lines for comparison. The inactivation/activation cost-time estimates for AK-260, preserved by either the standard or by the encapsulation methods, fell near the lower side of this wide range, even though an attempt was made to keep the estimates on the conservatively high side.

10. Supplementary information regarding activation cost-time differences among four AKA class ships is given in enclosure (5). At least for commercial shipyards, the data disclosed a wide discrepancy between planning estimates and returned costs, with costs invariably higher.

11. Wide variations in time and costs, especially for activation, are not

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unexpected. They may be attributable to significant differences in condition among ships when they enter inactivation. Other factors which may contribute to the wide spreads, are differences in practices among shipyards such as estimating and procedures, and in organization, priorities, workloads, and past experience.

12. The information contained in this letter includes data provided by the following facilities:

INACTSHIPFAC NORVA
INACTSHIPFAC NORVA CHASN DET
INACTSHIPFAC PHILA
NAVSHIPYD PHILA
NAVSHIPS 043

A. R. Fo
A. Motola
By direction

Copy to:
NAVMAT 03L
NAVSHIPS 03421
NAVSHIPS 0341
NAVSEC 6101E

SHIP INACTIVATION

COST-TIME BENEFIT ANALYSIS AND DETAILS OF ESTIMATES

1. Ship inactivation is accomplished by ship's force and by shipyard industrial force. In the case of AK-260 ship's force work was completed at NAVSHIPYD CHASN and industrial force work at NAVSHIPYD PHILA. It is believed that the time to complete ship's force work aboard AK-260 was somewhat longer than would have been required ordinarily, because the facility wished to make certain that all details including special work aboard a test ship were handled correctly. Shipyard industrial force work included the hull exterior and interior, and topside modifications required to accommodate the cover.

2. Industrial force activities usually begin when ship's force work is completed. However, for several reasons this practice could not be followed for AK-260, where a delay of approximately seven months after the completion of ship's force work occurred before the start of industrial force activity. Accordingly, redundant work was performed at an expense which otherwise would not have been incurred in order to provide protection for the ship during the interim period. Additional unanticipated industrial force expenses occurred in preparing the topside to assure an accurate fit with the cover.

3. All developmental costs including those of the contractor and the Navy were borne by the current program which is identified Phase I. Deduction of all estimated redundant and developmental costs from Phase I, provides the basis for Phase II estimates. Additional deductions are estimated for Phase III where the encapsulation concept is projected to maximum implementation. Details of the estimates for ship force work, for redundant industrial force work, and for the contractor are shown on pages 2, 3, and 4 respectively of this enclosure. A summary of inactivation cost-time data is given on page 5 of this enclosure.

INACTIVATION
SHIP'S FORCE WORK (AK-260)
REDUNDANT AND OTHER DEDUCTIBLE WORK ITEMS

DEPARTMENT	MAN-DAYS		
	CURRENT CHAPTER 9030 APPLIES		REVISED CHAPTER 9030 APPLIES
	PHASE I CURRENT AK-260 PROGRAM	PHASE II REDUNDANT WORK DEDUCTED FROM PHASE I	PHASE III ENCAPSULATION CONCEPT IMPLEMENTED TO FULLEST EXTENT
	RETURNED (1)	ESTIMATED	ESTIMATED (2)
ENGINEERING	3,572	4,200	3,900
DECK/HULL	1,382		
	4,954		
OPS/NAVIGATION	314	250	225
SUPPLY	341	340	340
WEAPONS	520	475	400
ADMINISTRATION	89	90	90
MED/DENTAL	60	60	60
TOTAL,	6,278	5,405	5,015
OR, ROUNDED	-	5,400	5,000

NOTES 1. DATA SOURCE: FINAL SHIPS PROGRESS REPORT, REFERENCE (d), INCLUDES WORK WHICH WOULD NOT HAVE BEEN NECESSARY, HAD THERE NOT BEEN AN APPROXIMATELY SEVEN MONTHS INTERIM DELAY BETWEEN COMPLETION OF SHIPS FORCE WORK AND START OF INDUSTRIAL FORCE WORK. REDUNDANT WORK INCLUDED BOOM STOWAGE RELOCATION; HANDLING EXPOSED TOPSIDE GEAR, CLOSING VENTS, SEALING ELECTRICAL OUTLETS STRIPPING AFT CONNING STATION, PRESERVING WINCHES WITH SOLVENT CUTBACK CORROSION PREVENTIVE, ETC.

2. BASIS OF ESTIMATE: LEAVING TOPSIDE GEAR IN, "AS IS" CONDITION TO MAXIMUM EXTENT, MAXIMIZING USE OF DEHUMIDIFIED AIR FOR EQUIPMENT PRESERVATION, AND REPLACING BACK-UP SOLVENT CUTBACK CORROSION PREVENTIVE WITH PRESERVATIVE LUBRICATING OILS FOR PRESERVATION OF MACHINERY COMPONENTS, WHICH IS DESCRIBED MORE FULLY IN REFERENCE (e).

INACTIVATION
INDUSTRIAL FORCE WORK (AK-260)
REDUNDANT TOPSIDE MODIFICATIONS
COST-TIME ESTIMATES

		COSTS $K			MAN-DAYS		
		FROM	TO	SAVINGS	FROM	TO	SAVINGS
1.	COVERING AND REOPENING STACK	4.0	0	4.0	30	0	30
2.	MOORING STATION ENCLOSURES AIR-LOCK VALVES a. FABRICATING AND INSTALLING ORIGINALS b. CLOSING ORIGINALS c. GASKETING PROBLEMS ORIGINALS	2.5	0	2.5	15	0	15
3.	REPLACEMENT OF CUSTOM MADE METAL AIR DUCTING BY STANDARDIZED REINFORCED PLASTIC DUCTING	49.7 (1)	10.0 (2)	39.7	452	77	375
4.	FOUNDATION FOR AND INSTALLATION OF EMERGENCY POWER GENERATOR	1.5	0	1.5	10	0	10
5.	ADDITIONAL WORK TO SEAL MOORING STATION ENCLOSURES	2.0	0	2.0	20	0	20
	TOTALS	59.7	10.0	49.7	527	77	450

NOTES: (1) FROM SHIPS DEPARTURE REPORT, REFERENCE (f).
(2) USING SAME PROPORTION, APPROXIMATELY 5:1, USED IN RECOMMENDATION NO. 4 OF NAVSHIPYD PHILA VALUE ENGINEERS, REFERENCE (g).

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CONTRACTOR'S ESTIMATED PRICE AND PRICE REDUCTION FOR A FOLLOW-ON SHIP COVER UNIT (1)

(Costs based on current material, labor, and burden)

	COLUMN 1 Identical to original unit; for identical ship.	COLUMN 2 Near identical (same overall design configuration, limited design, detail differences), for a sister ship with some fitting alterations.	COLUMN 3 Similar size & configuration. New design for a different
I. Estimated Price. Supply of materials and services identical to those previously supplied under the initial developmental program, less the emergency power generator and pallet handling equipment.....	$170,000	$190,000	$215,000
II. Approx. final price of original program (contract)..... $328,000			
III. Price Reduction (II - I).....	$158,000	$138,000	$113,000
IV. Breakdown of price reduction (III above), approximate:			
A. Non-recurring developmental engineering cost.....	$ 41,000	$ 44,000	$ 51,700
B. Non-recurring design engineering cost.....	$ 60,000	$ 36,000	---
C. Non-recurring manufacturing costs (i.e., developmental re assembly techniques).....	$ 19,000	$ 20,000	$ 23,300
D. Unanticipated material and labor (engineering, shop, lab, QA) costs relative to material supply problems.....	$ 14,000	$ 14,000	$ 14,000
E. Unanticipated labor and "other direct" costs relating to Navy delays at Philadelphia.....	$ 11,000	$ 11,000	$ 11,000
F. Removal of supply of emergency power generator and pallet handling equipment.....	$ 13,000	$ 13,000	$ 13,000
V. Improved pallet handling equipment, additional cost.....	$ 9,000	$ 9,000	$ 9,000

NOTE: 1. Based on information included in enclosure to reference (h), and telephone discussion between D. Randall, Birdair Structures, and H. E. Achilles, NAVSHIPRANDCEN, Annapolis Laboratory of 30 Jun 1972.

SHIP INACTIVATION
COST-TIME BENEFIT ESTIMATES-SUMMARY

	AK 260							
	Naval Ship Technical Manual							
	Current Chapter 9030 Applies						Revised Chapter 9030 Applies	
	Standard Method Estimated		Topside Encapsulation					
			Phase I - Current(3)		Phase II(5)		Phase III(7)	
Facility	Man-days	Cost $K(1)	Man-days	Cost $K(1)	Man-days	Cost $K(1)	Man-days	Cost $K(1)
Ships Force	6,100	610(2)	6,278	627.8(2)	5,400	540(2)	5,000	500(2)
Naval Shipyard Production Department	30	6	33	6.0	33	6	33	6
Naval Shipyard Industrial Force Hull	4,450	470	2,496	261.6	2,400	250	2,300	240
Topside Modifications	-		3,687	394.7(4)	3,257	345	2,400	255
Design Division	200	25	1,110	131.0	200	25	200	25
Contractor	-	-	NA	328.3	NA	179	NA	197
NAVSHIPRANDCEN Annapolis	-	-	945	149.7	220	40(6)	220	40(6)
Naval Photographic Center	-	-	NA	3.0	0	0	0	0
TOTALS	10,780	1,111	14,549	1,902.1	11,490	1,385	10,153	1,263
Time to complete, months	5		7		5		3 1/2	

(1) Constant dollars used throughout.
(2) Ships force man-day rate normalized at $100/man-day as for industrial force NAVSHIPYD Phila.
(3) Includes all estimated developmental and redundant costs, both contractor and U. S. Navy.
(4) Program charged only with $355K. Excess absorbed by other facility.
(5) Excludes all estimated developmental and redundant costs, both contractor and U. S. Navy.
(6) Assuming coordination of program by NAVSHIPRANDCEN Annapolis.
(7) Encapsulation concept implemented to fullest extent.

INACTIVE SHIP MAINTENANCE

COST-TIME BENEFIT ANALYSIS AND DETAILS OF ESTIMATES

1. Comparative maintenance cost-time estimates over a 15 year period for AK-260 preserved either by standard or topside encapsulation procedures are summarized on page 3 of this enclosure. Preservation by topside encapsulation is the more expensive method in terms of both money and man-days. This is attributable to increased power costs incurred because of the need to operate five instead of two air dehumidification machines, and to estimated additional labor for maintaining the cover.

2. Power cost estimates are based in part on the results of a survey of USS TERROR (MMF 5) made by INACTSHIPFAC PHILA. The results should apply reasonably well to the AK-260, because hull dimensions of the two ships are similar. Details of the power cost estimates over the 15 year anticipated life span of the topside cover are shown in the following table. Constant dollars are assumed throughout the period.

Total Power Costs for USS TERROR/YR	$ 3,400	
Less, Power Costs for 2D/H units/YR	1,148	(1)
Other Power Requirements/YR	2,252	

Applying above data to AK-260

	PRESERVATION METHOD	
	STANDARD	TOPSIDE ENCAPSULATION
D/H Machines		
Number required	2	5
Power cost/yr	$ 1,148	$ 2,870
Pressurization Blowers		
One Low Pressure/yr	-	86
One High Pressure/0.1yr	-	9
Power cost/yr, blowers	-	95
Power Costs/YR		
D/H Units + Blowers	1,148	2,965
Other	2,252	2,252
Total	3,400	5,217
or rounded		
Power Costs/15 years	51,000	79,000

NOTE (1) Based on power costs shown on page 25 of reference (i)

5. Maintenance Labor costs are normalized at $ 23.50 per man-day, the INACTSHIPFAC PHILA civilian rate applied for USS TERROR.

INACTIVE SHIP MAINTENANCE
COST-TIME BENEFITS ESTIMATES - SUMMARY

Maintenance Item	AK 250							
	Present Chapter 9030 Applies						Revised Chapter 9030 Applies	
	Standard Method[1]		Topside Encapsulation[1]					
			Phase I - Current		Phase II		Phase III	
	Man-days	$ Costs[2],[3]	Man-days	$ Costs[3]	Man-days	$ Costs[3]	Man-days	$ Costs[3]
Electrical Ex D/H units D/H machines and related Ship protection	192	Labor + material 8,875	229	Labor + material 11,225	229	Labor + material 11,225	229	Labor + material 11,225
Power, total	-	3,400[4]	-	5,200[4]	-	5,200[4]	-	5,200[4]
Total/year	192	12,275	229	16,426	229	16,426	229	16,426
Total/15 years	2,880	184,125	3,435	246,390	3,435	246,390	3,435	246,390
Or rounded	2,900	185.2K	3,450	246.4K	3,450	246.4K	3,450	246.4K

[1] Only two air dehumidifying machines required for standard method; five units required for topside encapsulation.

[2] Maintenance cost estimates based in part on results of a survey of costs for USS TERROR made by INACTSHIPFAC Phila. USS TERROR and USS BETELGEUSE have similar hull dimensions so that maintenance costs for USS BETELGEUSE preserved by standard method should be similar to those for USS TERROR.

[3] Labor costs normalized at $23.50 per man-day for INACTSHIPFAC Phila civilians and NOT at $100 per man-day naval shipyard industrial force rate.

[4] Power costs normalized at $0.0125/kwh for entire period.

SHIP ACTIVATION

COST-TIME BENEFIT ANALYSIS AND DETAILS OF ESTIMATES

1. ESTIMATED SAVINGS, PHASE II VS PHASE I

A review of the activation work package for AK-260 on 30 June 1971 with INACTSHIPFAC PHILA disclosed that many activation work items need not have been planned, if the inactivation industrial force work had followed without interruption ship's force work aboard the ship. Deducting unnecessary work indicated an estimated savings of 415 man-days from the total estimate of 11,663 man-days for Phase I, or an estimated 11,248 man-days for Phase II.

2. ESTIMATED SAVINGS, PHASE III VS PHASE I

a. It is assumed that with the implementation of revised Chapter 9030 the time required to activate a component would be approximately equal to the time needed for its inactivation. For ship's force work during inactivation savings of 1,278 man-days have been estimated. In accordance with this assumption the same number of man-days could be saved during activation.

b. Simplification of topside modifications, as shown in Recommendation No. 4 of reference (a), should afford labor savings in activation time as exemplified by the following:

- Reduction in number of metal mooring station enclosures from 10 to 2.
- Replacement of custom made metal ducting for the dehumidified air by standarized flexible reinforced plastic ducting.

A savings of perhaps 30 man-days is estimated for the above items.

c. Implementation of the recommendations for revising Chapter 9030 with respect to below decks machinery as described in reference (e) would be expected to effect a significant reduction in activation labor. A savings of some 250 man-days is estimated.

d. Deduction of the estimated total 1,558 man-day savings from the 11,663 activation man-days for Phase I provides an estimate of 10,105 man-days for Phase III. A summary of activation estimates is shown on page 2 of this enclosure.

SHIP ACTIVATION

COST-TIME BENEFITS ESTIMATES - SUMMARY

AK-260

NAVAL SHIP TECHNICAL MANUAL

	PRESENT CHAPTER 9030 APPLIES			REVISED CHAPTER 9030 APPLIES	
	STANDARD METHOD OF PRESERVATION	TOPSIDE ENCAPSULATION PHASE I CURRENT AK-260 PROGRAM	TOPSIDE ENCAPSULATION PHASE II REDUNDANT ITEMS DEDUCTED FROM PHASE I	TOPSIDE ENCAPSULATION PHASE III ENCAPSULATION CONCEPT IMPLEMENTED TO FULLEST EXTENT	ESTIMATED SAVINGS: STANDARD LESS PHASE III
MAN-DAYS (1)	11,996	11,663(2)	11,248	10,105	1,891
MATERIALS, $K	336.7	336.7(2)	334	334	3
TOTAL COSTS, $K	1,536.3	1,503.0	1,458.8	1,344.5	191.8
TOTAL COSTS, $K ROUNDED	1,536	1,503	1,459	1,345	191
TIME TO COMPLETE, MONTHS	3	3	3	2	1

NOTE: 1. LABOR RATE NORMALIZED AT $100/MAN-DAY WHICH IS NAVSHIPYD PHILA INDUSTRIAL FORCE RATE.
2. ACTIVATION WORK PACKAGE DATA.

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COMPARATIVE INACTIVATION AND ACTIVATION COST-TIME ESTIMATES FOR SHIPS HAVING GENERALLY SIMILAR HULL DIMENSIONS

Ship Code	Method of Preservation	Shipyard at which ship Inactivated	Year of Inactivation	Inactivation Man-days			Inactivation Costs, $K			Activation		Inactivation plus Activation	
				Ships force	Industrial force	Total	Labor(1)	Material(2)	Total	Man-days	Costs Labor Only $K(1)	Man-days	Costs Labor Only $K(1)
LKA 57	Standard	Naval	1970	9,059	2,614	11,671	1,167.1	55.8	1,223	8,770	877	20,441	2,044
LKA 61	Standard	Naval	1971	9,369	3,807	13,176	1,257.6	48.2	1,306	17,631	1,763	30,207	3,021
LKA 93	Standard	Naval	1971	12,689	2,952	15,641	1,260.1	28.6	1,293	15,955	1,596	31,596	3,160
LKA 94	Standard	Commercial	1969	11,601	2,461	13,462	1,346.2	178.0	1,524	16,328	1,632	29,784	2,978
LKA 97	Standard	Commercial	1969	14,901	2,387	17,288	1,728.8	99.4	1,828	18,010	1,801	35,298	3,530
LKA 103	Standard	Commercial	1971	2,469	(3)	-	-	-	-	13,974	1,397	-	-
LPA 44	Standard	Unidentifiable	1970	13,850	2,414	16,264	1,624.4	52.5	1,677	10,961	1,096	27,205	2,721
LPA 194	Standard	Naval	1970	11,591	2,545	14,096	1,409.6	43.4	1,453	9,240	924	23,336	2,334
LPA 213	Standard	Naval	1970	9,959	2,996	12,895	1,289.5	56.8	1,346	11,291	1,129	24,146	2,415
LPA 220	Standard	Commercial	1970	14,797	1,621	16,938	1,693.8	54.1	1,748	22,823	2,282	39,761	3,976
AKS-32	Standard	Naval	1969	8,427	2,206	10,633	1,064.3	33.2	1,029	24,357	2,436	35,000	3,500
AE-12	Standard	Commercial	1970	6,419	2,414	8,883	888.3	33.2	922	14,348	1,435	24,231	2,423
AK-260	Standard	Naval	1971	6,100	4,680	10,780	1,078.0	33.0	1,111	11,996	1,536	22,776	2,278
	Topside Encapsulation Phase I	Naval	1971	6,478	2,529	14,349(4)	1,494.9	447(5)	1,902	11,503	1,503	26,212	2,621
	Phase II	Naval	1971	5,400	2,433	11,490(4)	1,149.0	236(5)	1,385	11,248	1,459	22,738	2,274
	Phase III	Naval	1971	5,000	2,333	10,153(4)	1,015.3	248(5)	1,263	10,149	1,349	20,202	2,020

(1) All labor costs normalized at $100/man-day to facilitate comparison, although rates vary according to type and grade of position.
(2) No escalation.
(3) Information could not be located.
(4) Includes NAVSHIPYD Phila Industrial Force and Design Division plus NAVSHIPMANDCEN Annapolis.
(5) Includes estimated cost of contract for design and fabrication of topside cover.

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SHIP ACTIVATION

FOUR AKA CLASS SHIPS (1)

ESTIMATED AND FINAL COSTS

YEAR OF ACTIVATION		1961 (2)			
COMMERCIAL SHIP YARD LOCATION		GULF COAST		PACIFIC COAST	
SHIP CODE		AKA 53	AKA 92	AKA 54	AKA 93
ACTIVATION TIME, DAYS TO COMPLETE		86	86	66	70
MAN-DAYS	(3)	16,604	15,346	28.623	26.224
PLANNING ESTIMATE, $K	(4)	1,128	916.3	1,700	2,000
CONTRACT AWARD PRICE, $K	(4)	730.9	656.0	882.0	925.2
ACTIVATION FINAL COST, $K	(3) (4)	1,999	1,074	2,385	2,174

Notes 1. DATA FROM FILES OF SHIPS 043

2. REACTIVATED DURING EMERGENCY

3. RETURNED MAN-DAYS & COSTS INCLUDE OVERTIME NOT SEPARABLE FROM INDIVIDUAL TOTALS

4. PRICES & COSTS IN 1961 DOLLARS

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APPENDIX M

TOPSIDE ENCAPSULATION OF USS BETELGEUSE (AK 260)

Figure 1-M - USS BETELGEUSE (AK 260), Topside Modifications Under Way

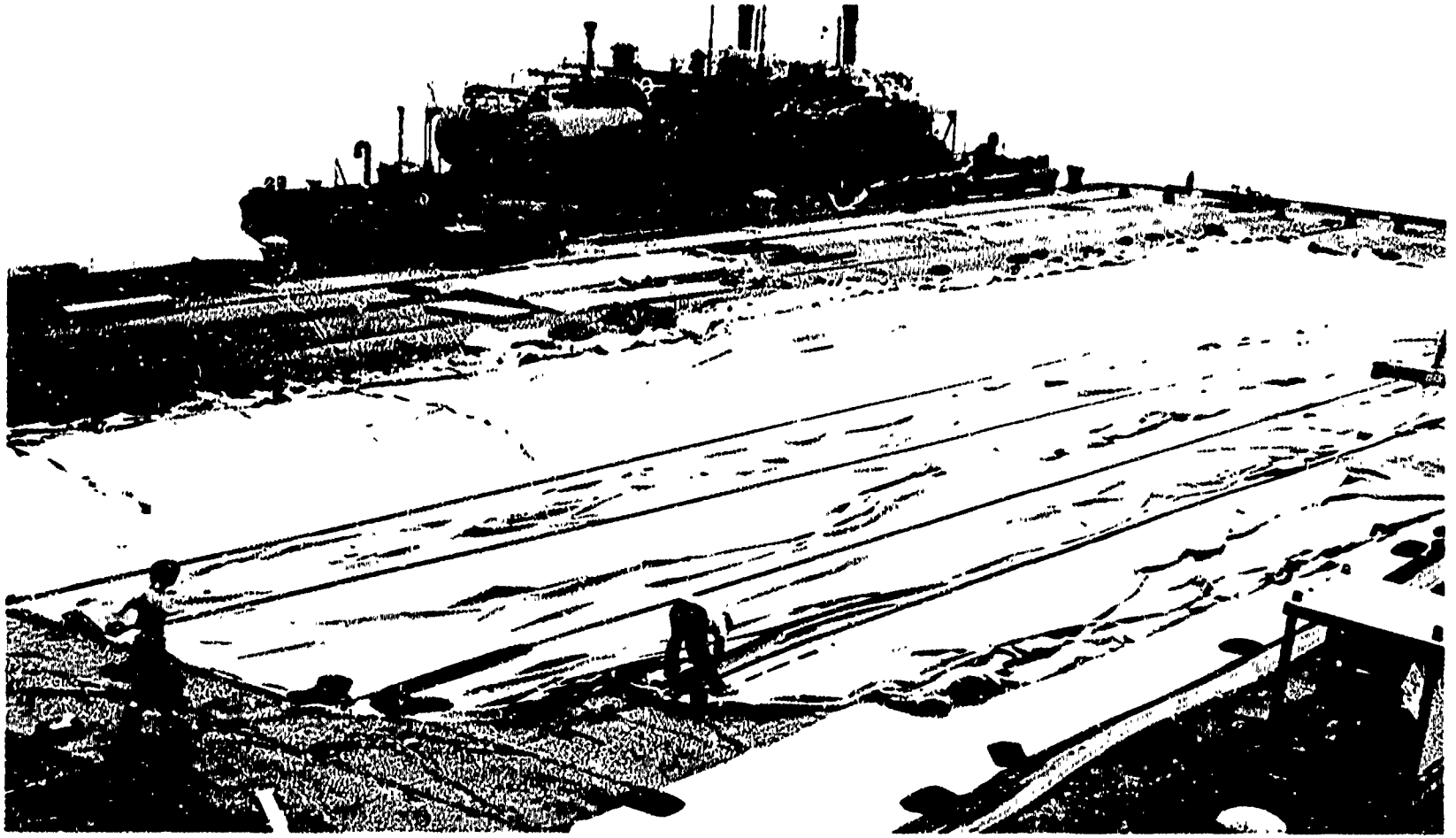

Figure 2-M
Cover Layout on Pier, Preparations for Bonding Transverse Cables to Cover

Figure 3-M
Positioning Transverse Cable on Cover

Figure 4-M
Bonding Transverse Cable to Cover

Figure 5-M
Applying Hypalon Paint to Bonded Cable

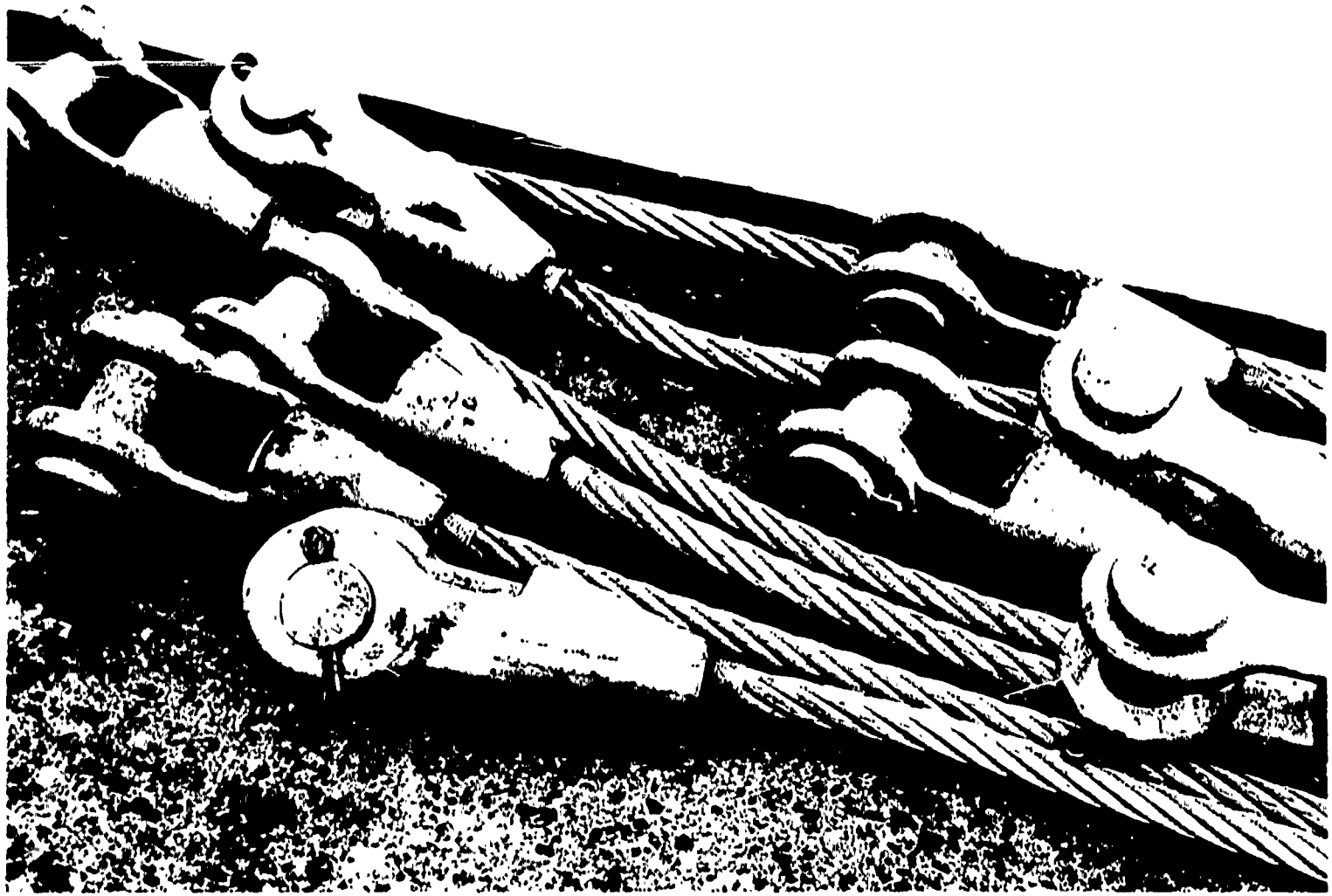

Figure 6-M
Transverse Cables Fitted into Sockets of Clevis Assemblies

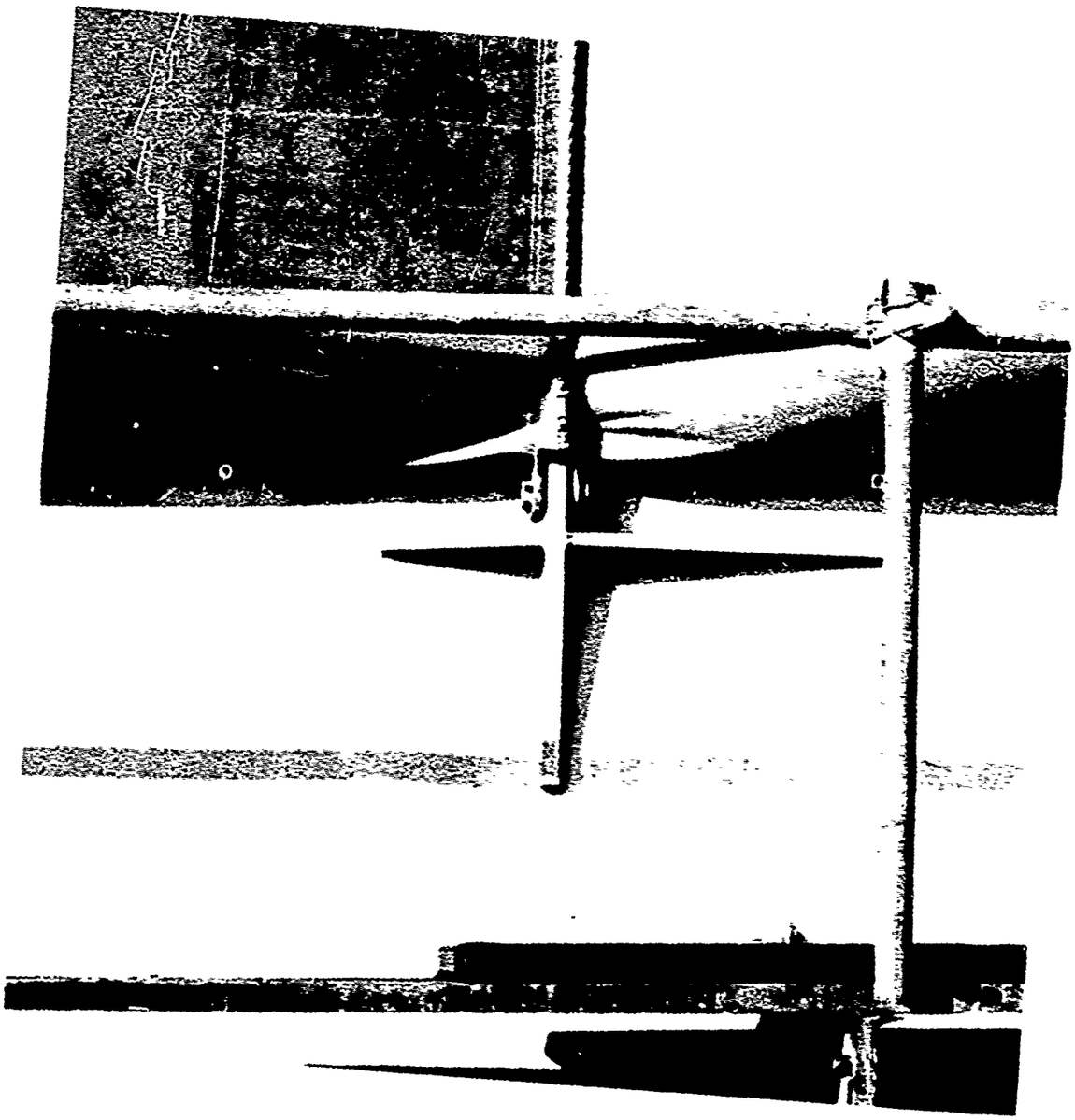

Figure 7-M
Attachment of Transverse Cable to Padeye

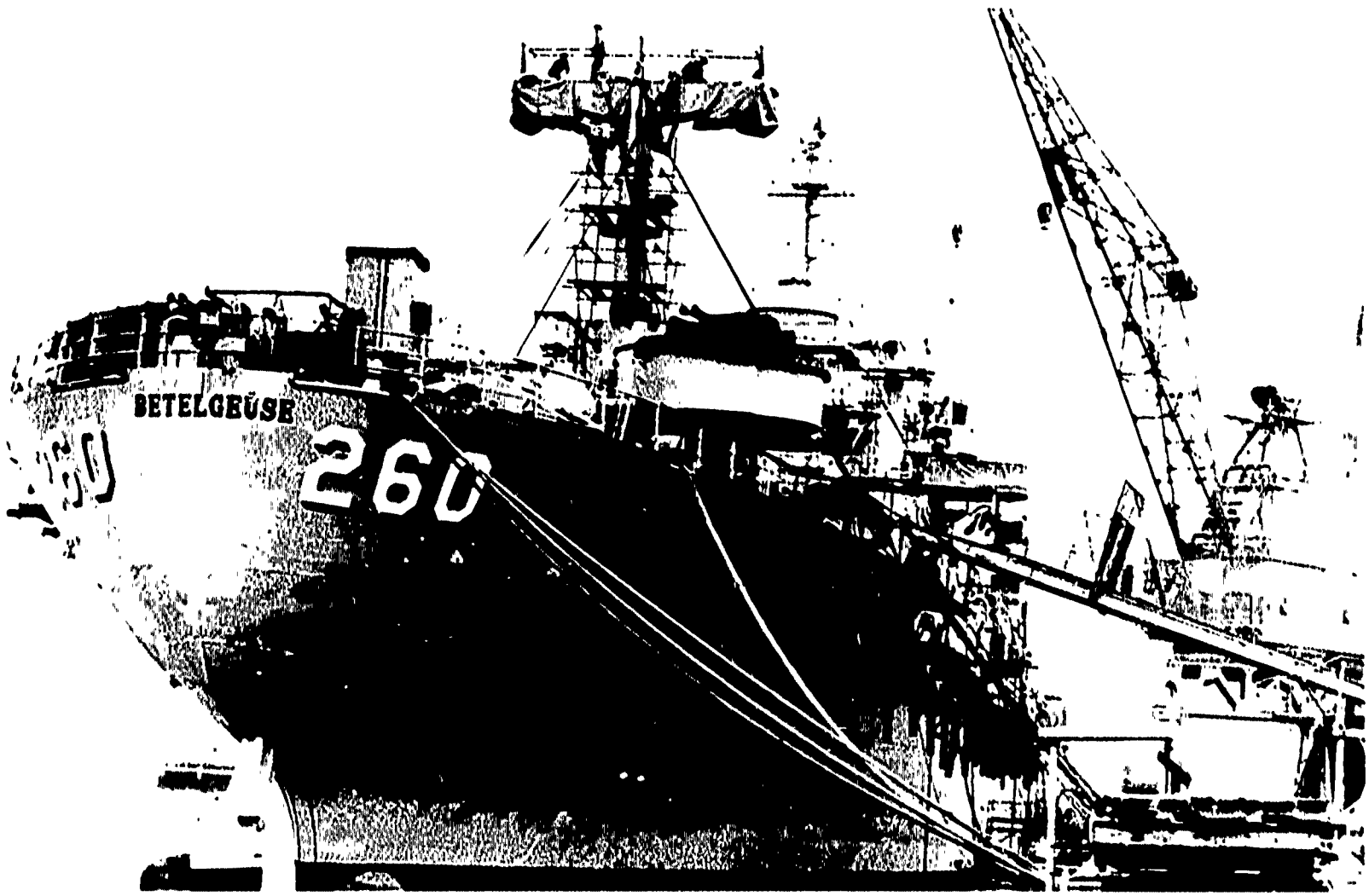

Figure 8-M - Padding Installed on Crosstree of Aftermost Mast, Aft Starboard Gun Tub, and Starboard Bridge Wing of AK 260

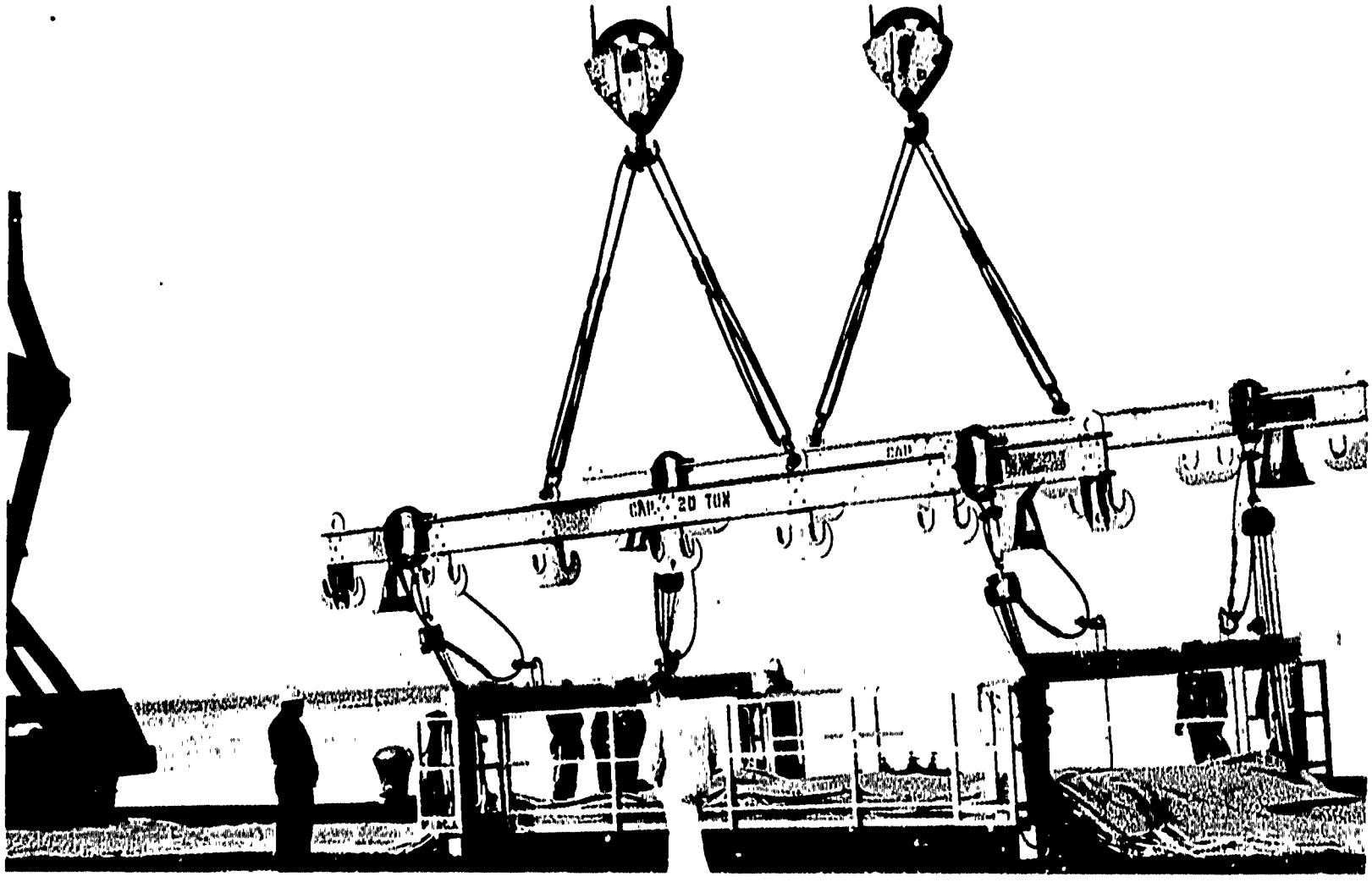

Figure 9-M
Cover Folded on Unloading Pallets

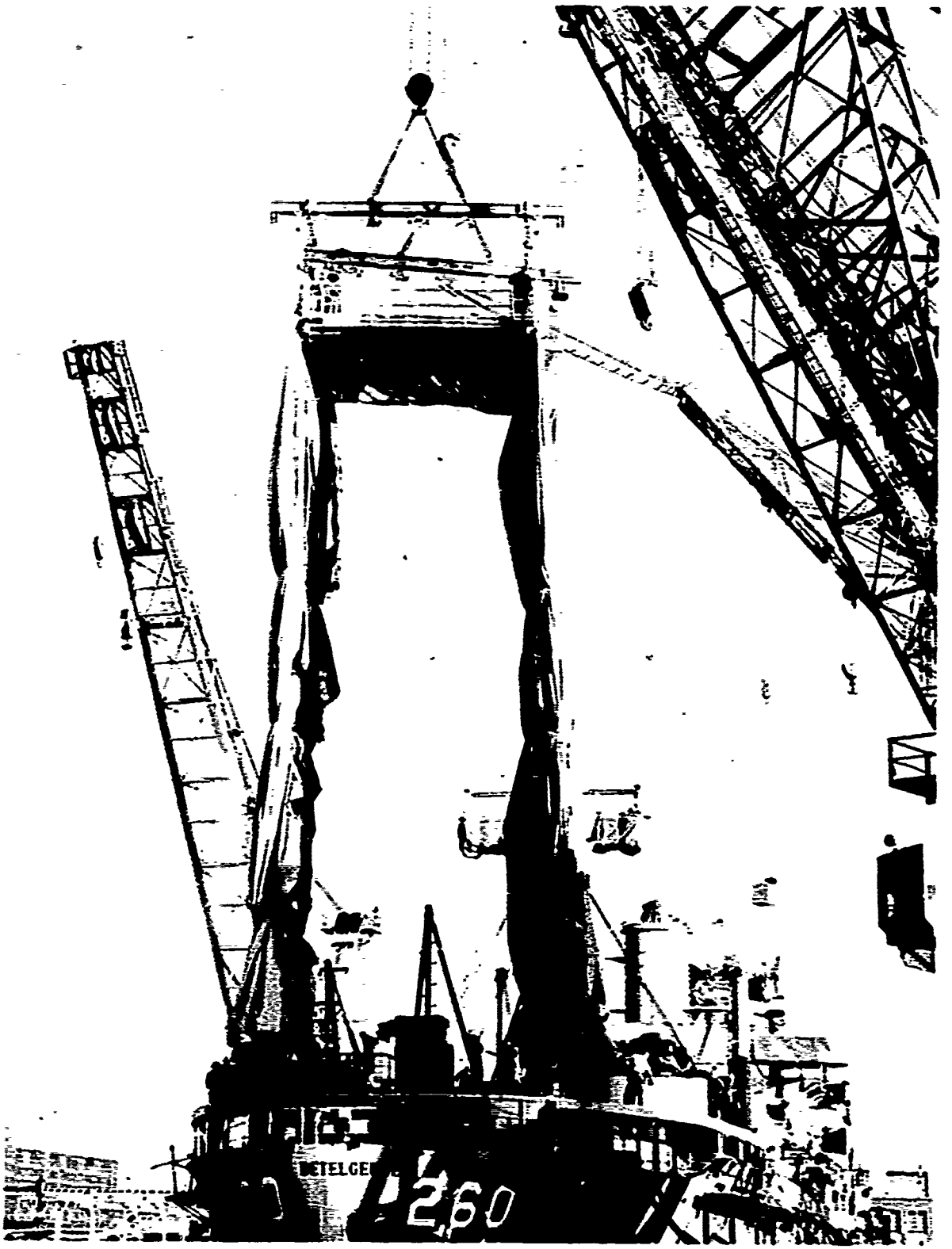

Figure 10-M
Cover Lifted Over Stern

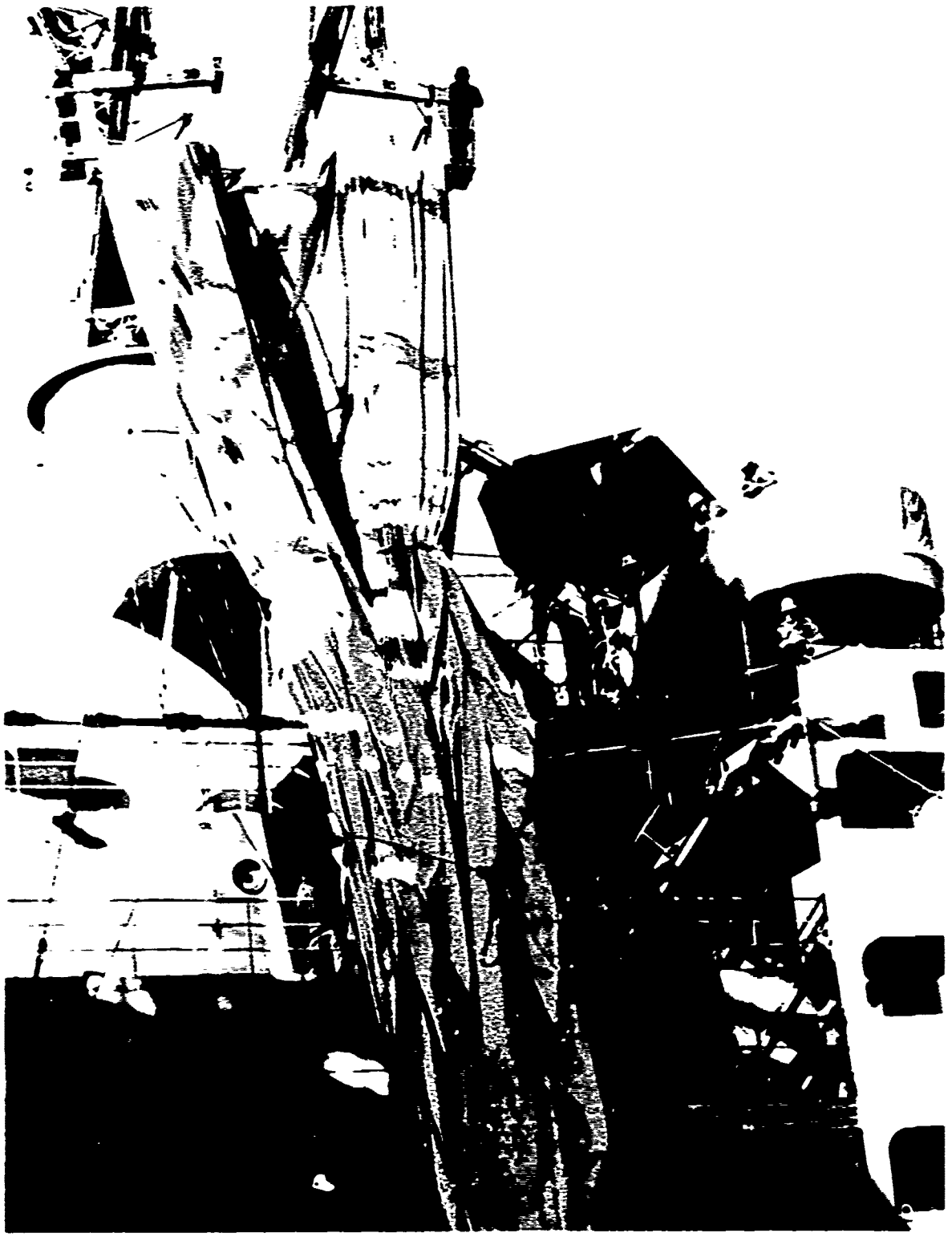

Figure 11-M
Cover Positioned Over Stack;
First Cable Being Attached to Padeye

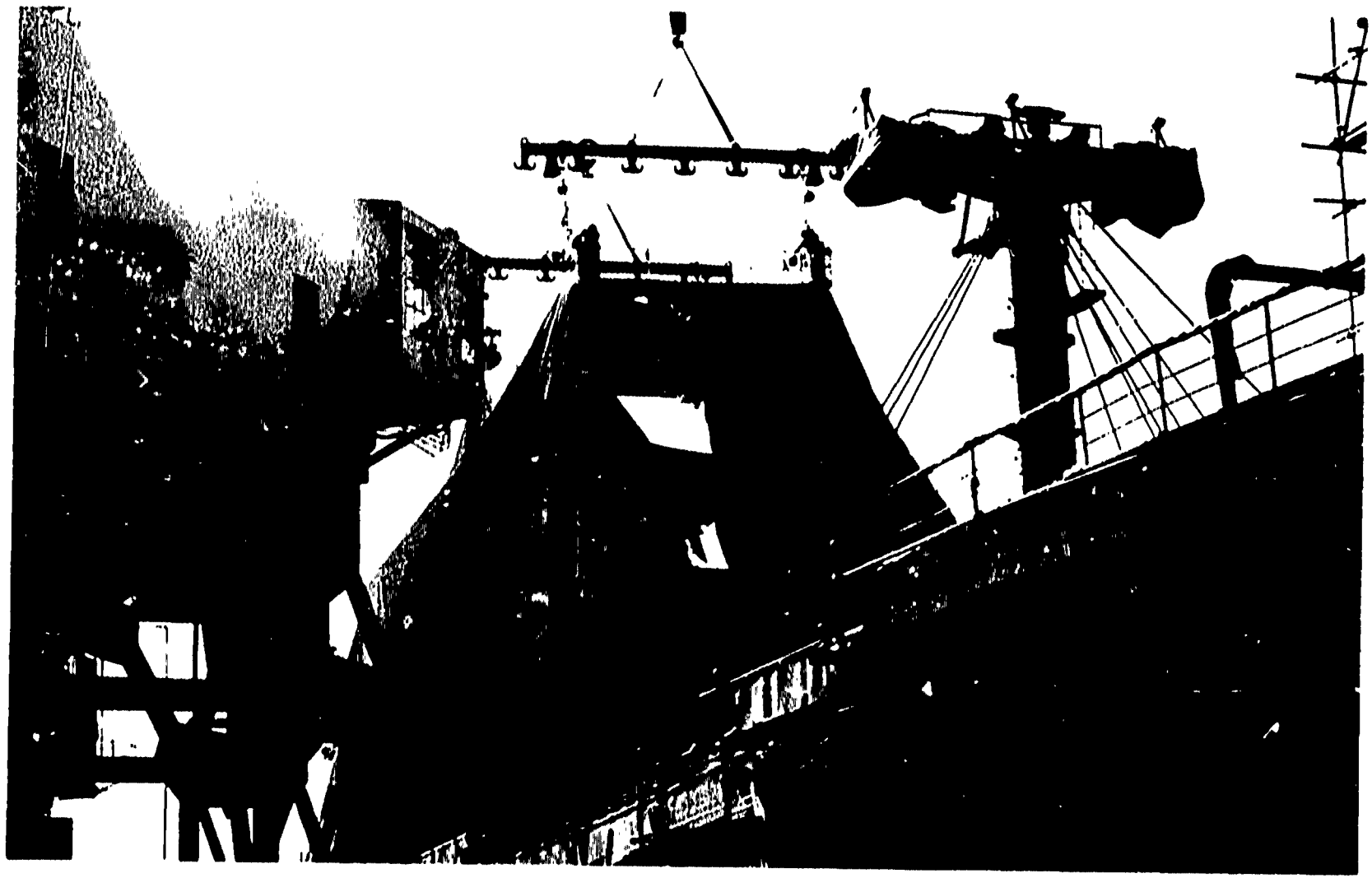

Figure 12-M
Draping Cover Forward

Figure 13-M
Draping Cover Over Bow Gun Tubs

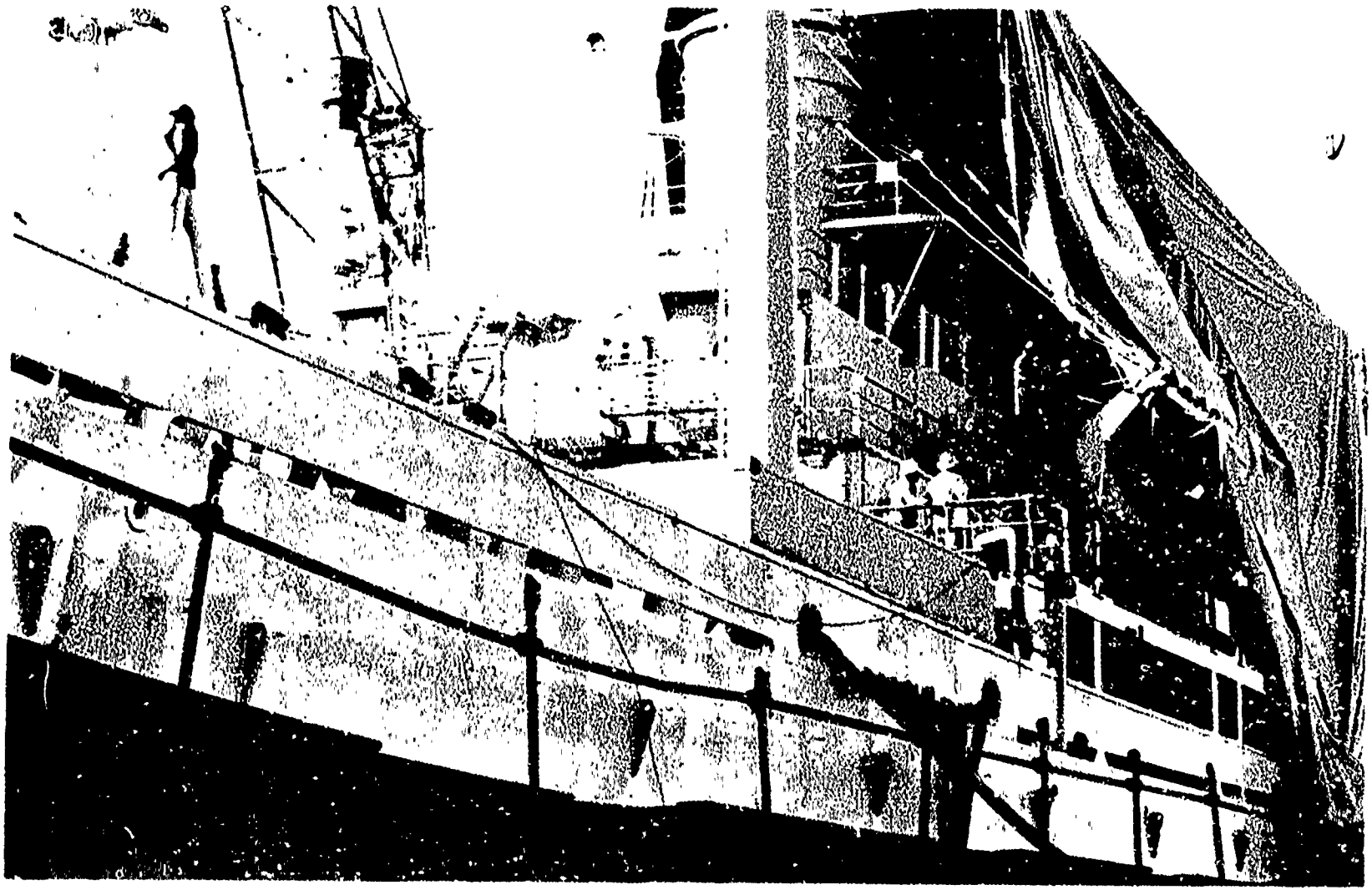

Figure 14-M
Draping Cover Aft Over Boat Davit

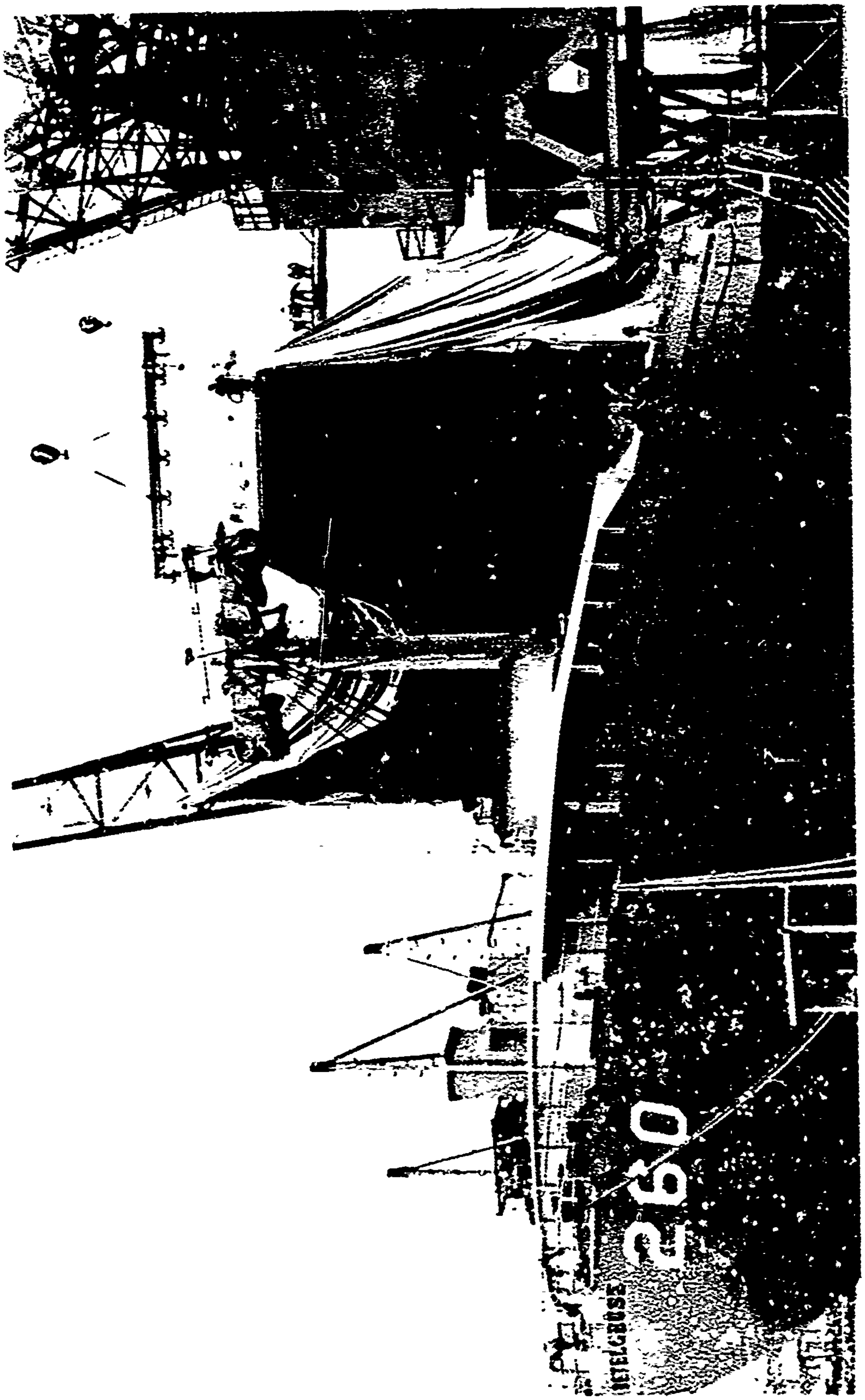

Figure 15-M
Draping Cover Aft

Figure 16-M
Draping Cover Over Stern

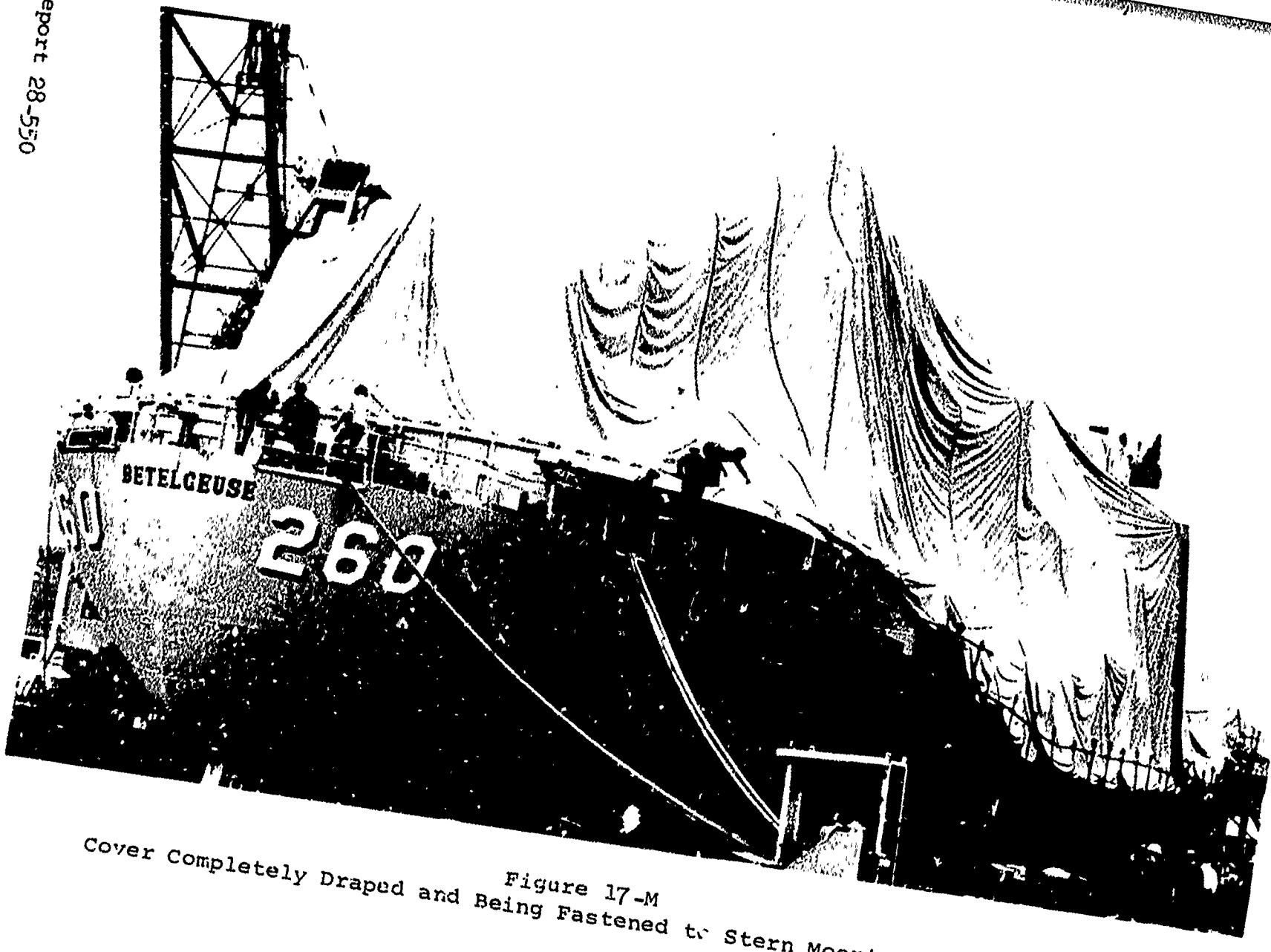

Figure 17-M
Cover Completely Draped and Being Fastened to Stern Mooring Enclosure

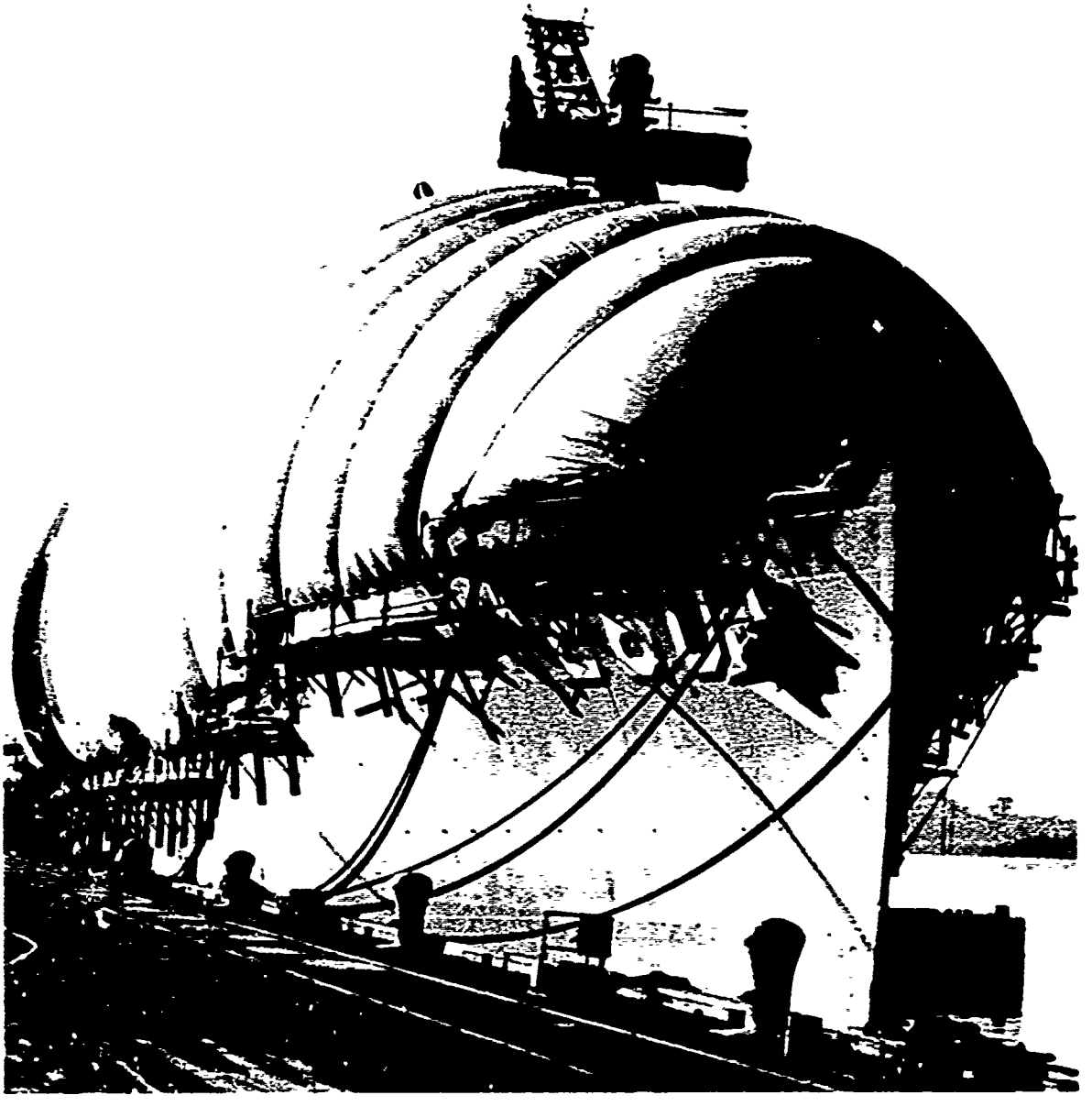

Figure 18-M
Bow View, Topside Enclosed
Within Inflated Cover

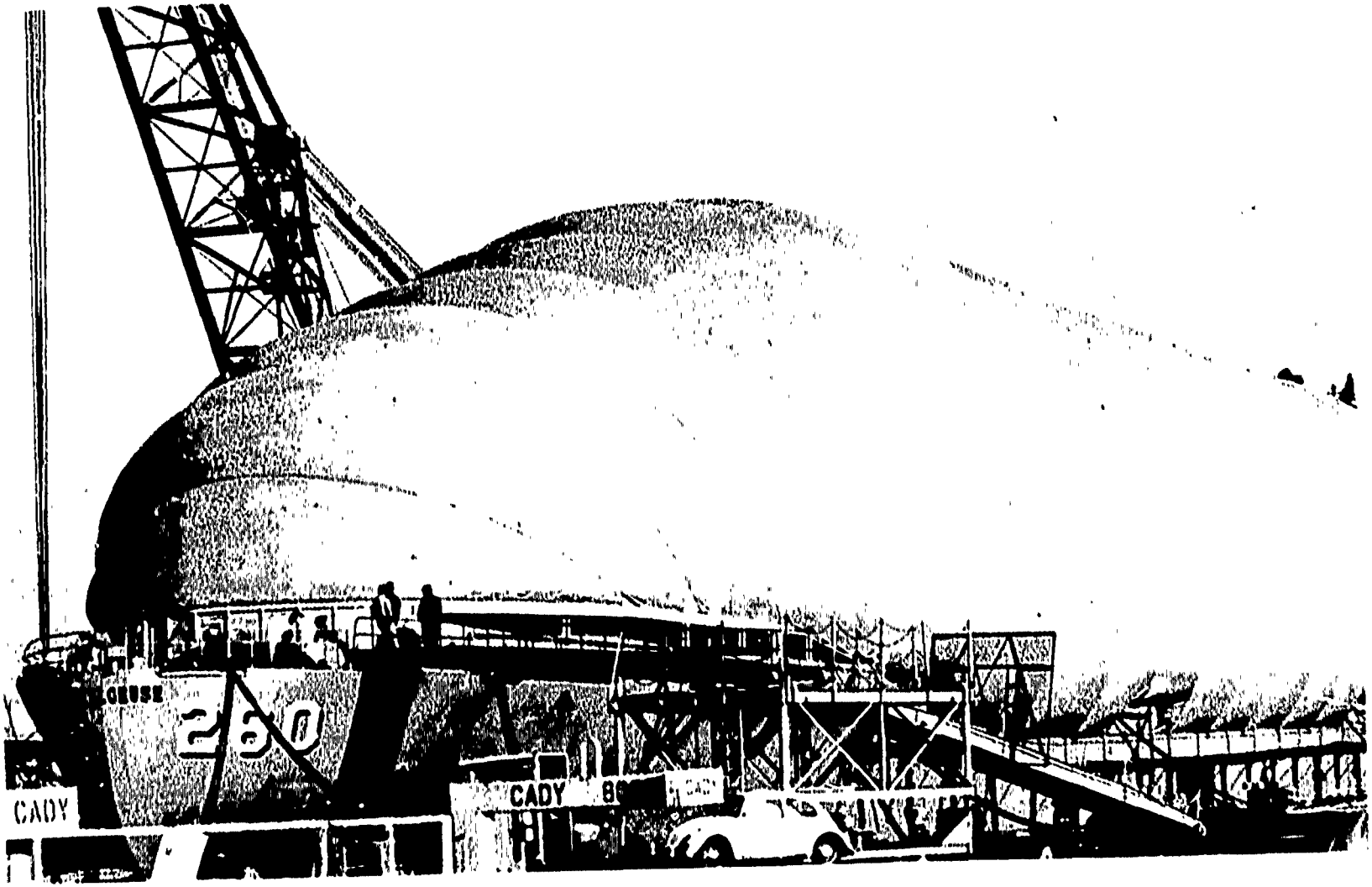

Figure 19-M
Stern View of Ship With Inflated Cover

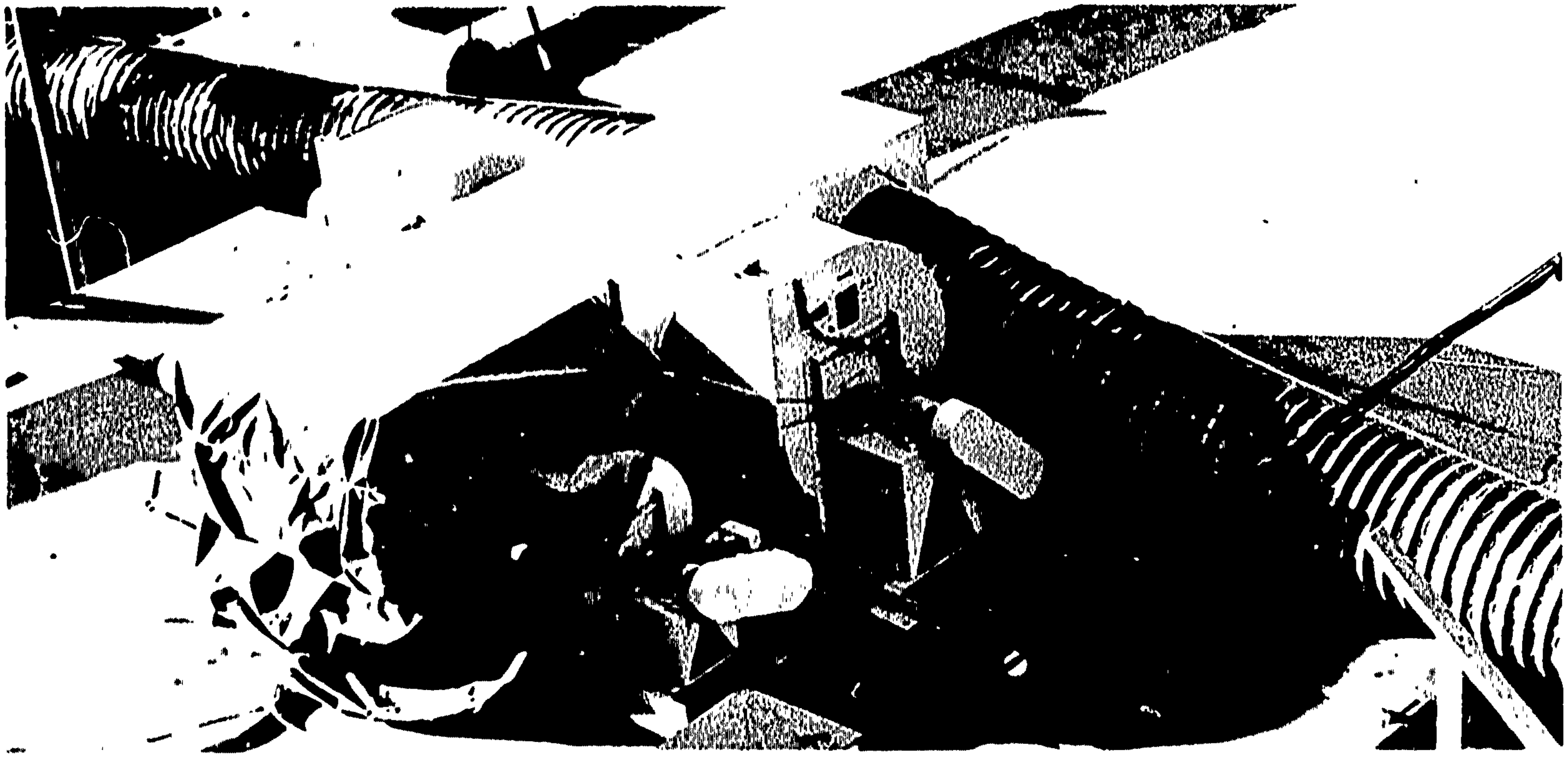

Figure 20-M
Air Blowers and Air Intake Ducts of Pressurization System
Prior to Installation of Cover